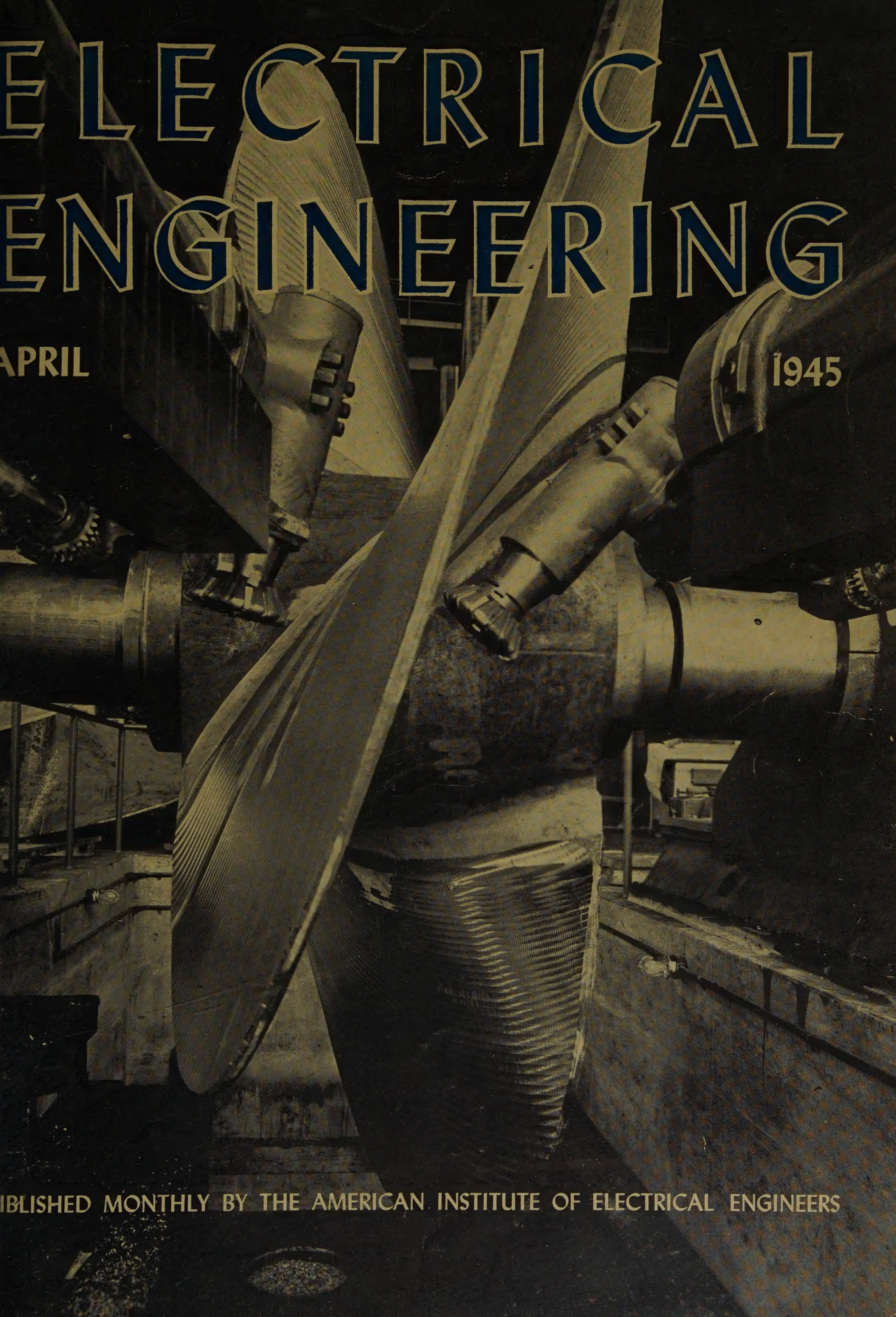
ELECTRICAL ENGINEERING

APRIL 1945



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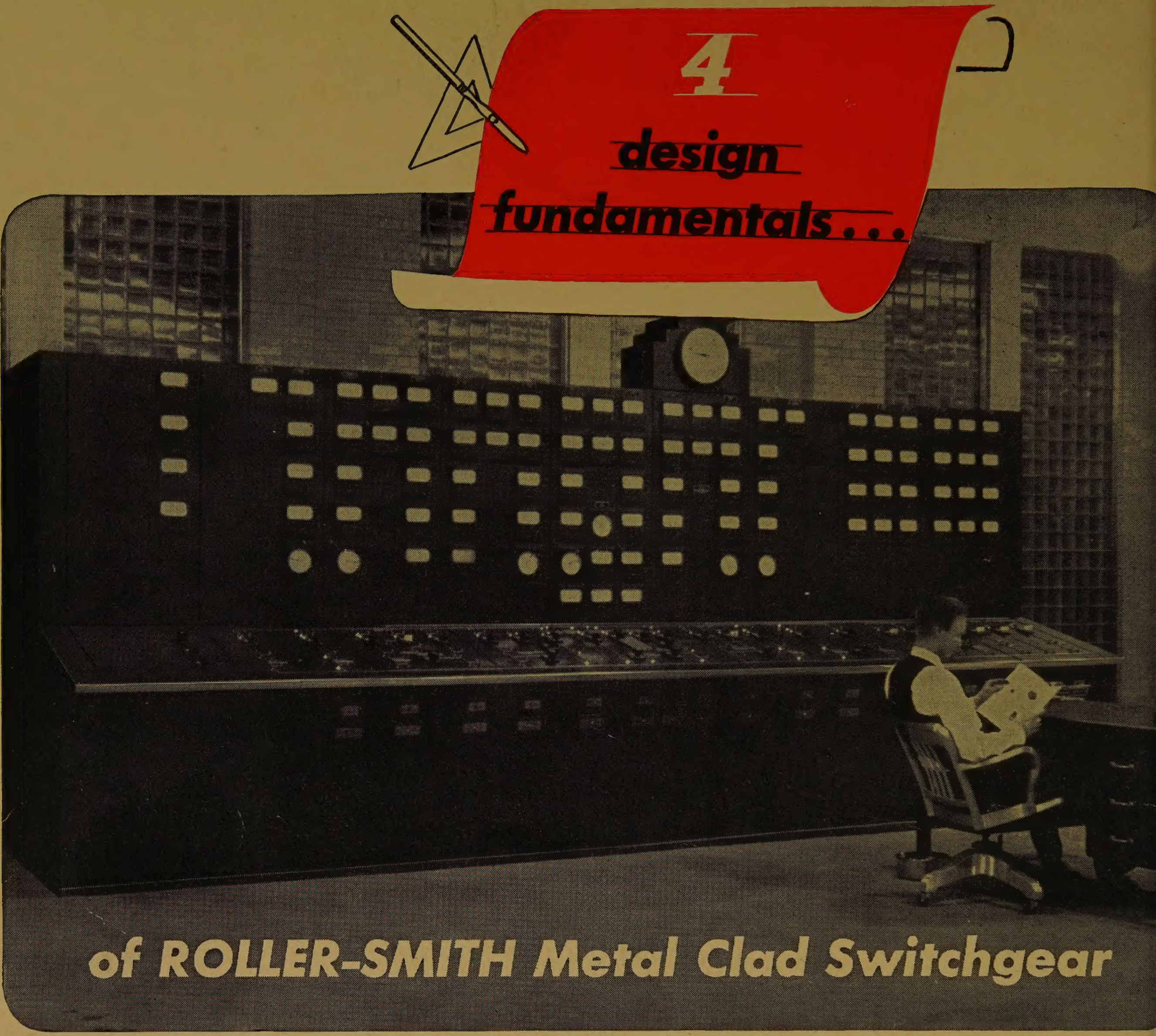

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1945

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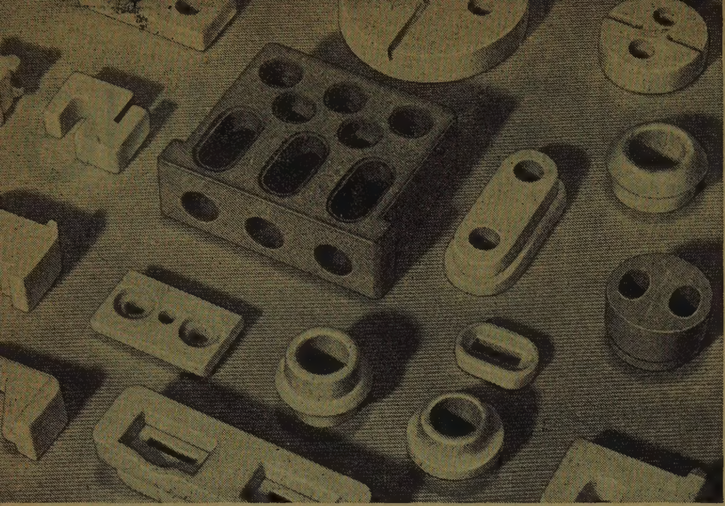

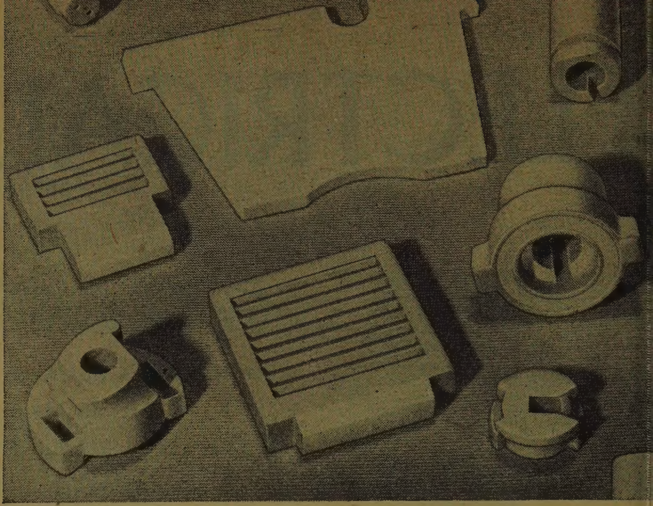

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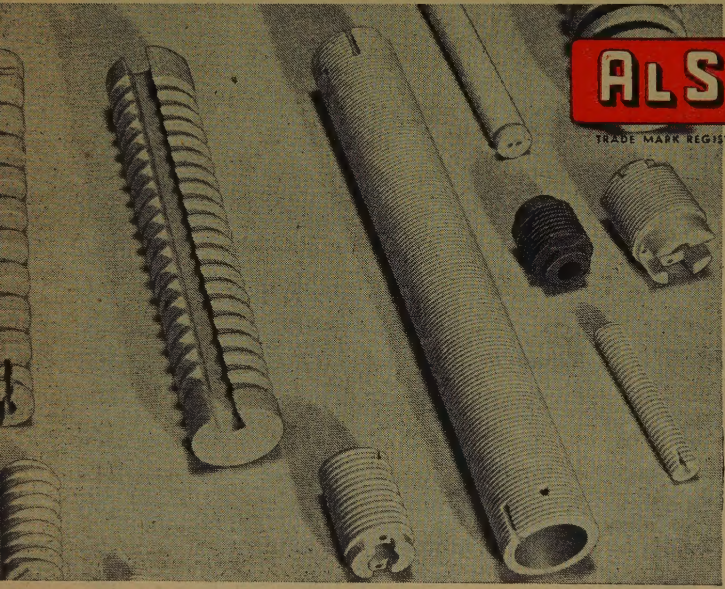

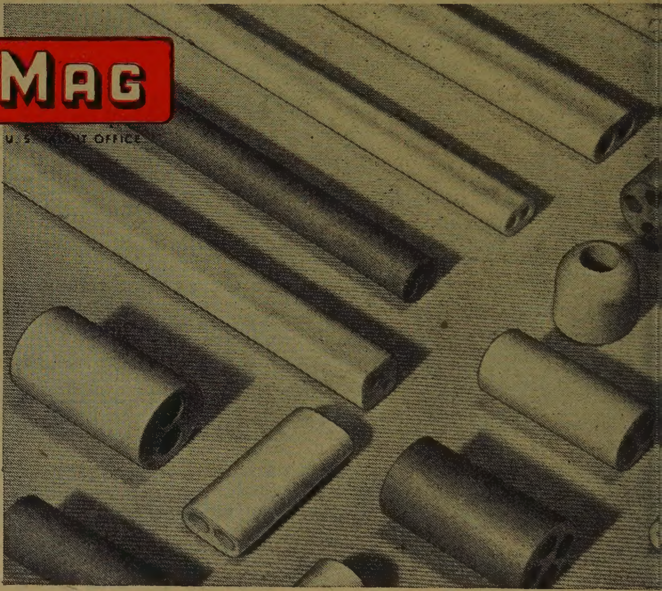

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VOLUME 64, NUMBER 4
APRIL 1945

The Influence of Research on Victory in War

J. CARLTON WARD, JR.

There is no substitute for continued peacetime research and development and evaluation, if our Nation is to avoid disastrous wars in the future, contends this author, and he quotes various military and naval authorities who support his conclusions.

RESEARCH has had a profound effect on the course of this war. In engineering fashion, to develop the subject, we must start with the causes of war. They are essentially economic, political, religious, or cultural. Because human nature changes but slowly, these causes probably will be with us for as far ahead as we can see.

Now, if we look at our own history some very startling facts appear. For one thing, we have *not* been a peaceful nation. We have fought a major war once in approximately every 20 years, beginning with the Revolution, the War of 1812, the Mexican War of 1842, the Civil War of 1861, the Spanish-American War of the '90's, World War I of the late teens, and now World War II. I have omitted the Indian Wars, the insurrections, and minor troubles such as we have experienced in Central America, Haiti, and so forth.

It seems to me that we, as engineers with that experience, background, and data before us, have to look realistically ahead and project our past experience into the future. I do not predict another war in 20 years, but the experience curve goes off into dangerous and uncertain territory. Unless we introduce some new variables that will control the behavior—the social behavior—of nations, it is fairly reasonable to predict another war.

It is unfortunate that we do not teach the causes of war and the prevention of war instead of a glorified, sublimated, romantic view of wars of the past—for the most part utterly unreal. If you wish to prove that statement, you have merely to read of our American Revolution in a current Canadian school history. You will not recognize your favorite war.

TRAINING FOR WAR

Now, this is too broad a subject for us to try to cover here today, and it is not my title. However, in the prevention of war, or the possible prevention of war, it is obvious that there are some very fundamental considerations—one is having at hand at all times trained men or man power, modern equipment, and a professional group, thoroughly indoctrinated and trained in the art of war, the science of war, or however you prefer to describe the phenomenon of war. This involves our maintenance in this country of professional staff colleges, such as the Naval War College at Newport, R. I., the Army War College in Washington, and also all of the specialized Army schools and Naval schools.

We are very inclined in this country to turn our thinking on and off, politically, like a faucet—the way one throws a switch in an electric circuit. When we are at war, we are very interested in these subjects; when at peace we throw the switch. However, there must be continuity; there must be continued study and application of thought to these problems.

We are interested primarily in one small phase—a very important phase of these problems. That is research as it applies to the scientific side of war and as it ultimately flowers into methods, tactics, and weapons. Matériel is the broad term—and the use of matériel. I do not think I have to defend before you the theory that to be in the air with second-best airplanes is not a healthy place to be; or to be on a battle front with second-best tanks is not exactly an enviable spot; or to be at sea with slow improperly armed and defended Naval ships is not the ideal way to take a sea voyage.

Those are obvious things. Now, those ships, those tanks, and those airplanes were once modern. What made them second best? Obsolescence. Obsolescence in war weapons is a frighteningly rapid phenomenon. The Army today is engaged in defending before Congress a postwar view that aircraft is obsolete in four years. I wish we had the opportunity to discuss in detail that subject. It is fascinating.

I think you will have to agree that the Army's view is not far from a practical measure of what history in the past has proved to be the case. At the moment the political opinions of the country and in Congress support this type of thinking, and so, if we are to benefit in our political structure with a view toward prevention of wars in the future, we should take advantage of this opportunity to set our house in order and elevate our sights for the future.

RESEARCH AND DEVELOPMENT

It is very confusing to the average person to distinguish between the separate spheres of research and development. The terms are loosely used and, to my knowledge, have never been defined in a way with which everyone can agree. For the purpose of our paper today, we divide research and development into three processes.

1. The field of research as exemplified by the work of the National Advisory Committee of Aeronautics in our industry.
2. The field of development exemplified by placing those principles to work by private industry—engineering in a true sense; application of science in a true sense.
3. The field of technical specifications and evaluation, which is predominantly a Government function.

It is well to keep these three factors in mind, and their interrelation, in order to understand the problem as a whole and the politics of the problem. By politics I mean the preservation of a normal peacetime economy in the United States—an economy which will answer to the threat of war with the remarkable performance that you have witnessed in this World War.

GOVERNMENT AGENCIES

During the war we have created many emergency agencies. For instance, we have the Office of Scientific Research and Development and the National Defense Research Council. These are devices to put into Governmental machinery the scientific and research brains of the United States that are normally engaged in civilian activities and pursuits. They

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Essential substance of an address presented at the general session of the AIEE winter technical meeting, New York, N. Y., January 24, 1945.

J. Carlton Ward, Jr., is president and director of Fairchild Engine and Airplane Corporation, New York, N. Y.

come from universities, from laboratories, from private life, and from industry. These war emergency organizations are not proper agencies for a postwar period.

At present there is before Congress a bill to set up a national research committee which is being sponsored by the Army and the Navy. It would be a permanent agency to take the place of these wartime temporary agencies. You all know we have the National Academy of Sciences set up by a farsighted administration many years ago with the idea of having available in this country the best brains when and if the country needed them in a national emergency.

The NACA, on the other hand, is a permanent active research institute. The Naval Research Laboratory is another permanent institution covering a separate field, and there are many others. Such is the Government machinery by which the research function in peacetime is accomplished. The development function is accomplished, as I have stated, by private industry supplemented by special projects which at times are operated by the military branches where there is no existing private industry equipped to do the job.

In the evaluation phase there are a great many Government laboratories. In the Army there are the laboratories of the various technical branches of the Army Service Forces, such as ordnance, medicine, signal corps, engineers, and so on. In the Navy, there are the technical laboratories of the bureaus, such as ships, yards and docks, ordnance, medicine, and so forth. In the Army Air Forces there are the laboratories at Wright Field. The Bureau of Aeronautics of the Navy has similar facilities.

When one first reviews such a variety of laboratories and hears them described by various individuals as either research or development laboratories, the pattern is very involved. But if you analyze it according to the three functions I have mentioned, the pattern begins to clarify and the confusion is eliminated.

There is, of course, some overlapping, just as there is overlapping in the application of the words, "research" and "development," but this overlapping is minor. In the postwar world, however, it is very important that these functions be kept clearly separated if we are to preserve the economic structure of this country and maintain a healthy resourceful industry. Each has a permanent place and has a fulltime job to accomplish.

THE CASE FOR CONTINUOUS RESEARCH

A distinguished Naval officer, Admiral Van Keuren, who commands the Naval Research Laboratories, said:

> "I think no one will argue against the statement that as long as we have a Navy, so long must we have Naval research, and in my opinion we shall have to have a Navy—and a strong one—for a long, long time. Having been a technical adviser on two reduction-of-armament conferences, and having observed the tragic results and lack of results thereof, it is inconceivable to me that any victorious power will ever let down its guard again to the extent of crippling its Navy, all arguments about armaments bringing on war to the contrary, notwithstanding."

And again from a letter that Admiral Van Keuren wrote in December:

> "A fair average in peacetime is about five years from the idea to the application in service, though the range might vary from two to 15 years. In wartime the effort is to compress into two years or less what would ordinarily take five years or more. The result, of course, is that plenty of trouble arises in service, but something is often better than nothing at all. NDRC scientists with whom I have talked agree with the above ideas."

He attempts to set forth there the time between inception and use, which carries you through the research, the development, and the evaluation phases.

Now, from Professor Hunsacker's testimony before the Woodrum committee of the Congress:

> "The effects of accelerated enemy research and development in preparation for war helped to create an opportunity for aggression which was promptly exploited. This lesson is the most expensive we have ever had to learn. We must make certain that we do not forget it."

I wish all citizens had time to read the testimony that has recently been introduced before the Woodrum committee of Congress on this subject.

A very interesting development in our Government has occurred which has escaped the attention of most citizens. To look back, our Congress has built up a committee system, over a period of years, by evolution. Many people think it is archaic today, but whatever your view may be in that respect, one thing is clear—that this great country had no single committee of Congress to consider the formulation of an over-all military, naval, and air policy.

Such a task was split up among the Naval Affairs Committee, the Military Affairs Committee, the Budget and Appropriations Committees, the Maritime Committee, as well as various other committees. You can readily see with that organization there could be no over-all simple pattern of national-defense policy emerging. Not until 1944 did this great Nation have in its legislative halls a single committee to consider what is best for the country in formulating a top over-all policy under which these various segments of the problem could dovetail and fit together in a smooth pattern. This committee in the House of Representatives is popularly called the Woodrum committee.

Testimony before the Woodrum committee has been given on such subjects as the question of whether we should have a single department of national defense in place of our War and Navy Departments; the question of what our postwar policies should be on research and development. Many other related questions that should be dear to our hearts as citizens are now being testified to by outstanding experts. From these hearings I am sure will come forth, at least, a pattern of policy which in time should become more and more practical in the light of our past history and our future potentialities as a great world power.

And now, to return to the research and development problem, I would like to give you the example of the Flying Fortress. This airplane was started away back in 1935. It was not a good war-developed fighting machine until 1942—seven years. Probably you think of the Flying Fortress, as you properly should, as our first large air bombardment machine. Can you imagine what the results would have been, had we had to germinate and develop that idea since Pearl Harbor? The successor machine, the Superfortress, was started in 1939, and only just recently has the Army announced it as a battle-perfected bomber.

In this one example you can see the major argument for continued research and development. We do not like to say it, but we were a second-rate Naval and Army air power when this war hit us. You do not find many of our aviation leaders saying that. You do not find many of our military leaders saying that, but those are facts. Testimony has put them before Congressional committee hearings.

When I was in France in 1940 on an official mission and the Germans were breaking through in the North, a French air general said to us, "If America can give us about 500 modern pursuit planes and 600 tanks, we can stop the breakthrough." Our reply had to be that our country did not have 500 modern pursuit aircraft, nor did we have any modern tanks in 1940. Had *we* been attacked as France was attacked, you can draw your own conclusions.

You know that there *was* such a plan to attack us. That plan remained active in the German general staff until after the battle of Stalingrad in 1942. Many American citizens have not been alive to this fact.

THE FLYING FORTRESS—STAR WITNESS

So, to go back to the Flying Fortress, as our example, you find seven years of development and research and evaluation before you had the finished article. The first Flying Fortresses that we sent to England were defective in the sense that they had what we called blind spots in the tail. A great many of them perhaps were needlessly lost in the first missions on which they were sent.

I would like to read from General

Frank Carroll, who commands the engineering division at Wright Field, who spoke before the Society of Automotive Engineers recently. To quote:

"Let us look for a moment at some of these hurdles that research had to take before the *B*-29 could take to the air. High altitude means reduced temperature and reduced pressure. The effects of these two circumstances had to be counteracted because they not only influenced the operation of nearly every component of the aircraft, but they had a very definite effect upon the men who flew in them. As atmospheric pressure goes down, the horsepower of an engine is cut proportionally, so that its sea-level output is reduced 50 per cent when an altitude of 20,000 feet is reached. To keep up the manifold pressure, turbosuperchargers were designed, and problem number one was disposed of.

"But that was only the beginning; ignition systems were affected by high altitude also. If we maintain the same high pressure within the cylinders at high altitude that we normally maintain at sea level, then the ratio between the internal pressure and external pressure is increased. Electricity following the path of least resistance will tend to 'arc over' somewhere in the low-pressure area outside the cylinders rather than leap the spark-plug gap and ignite the compressed gasoline vapor within the cylinders. The electrical engineers have gone to work and developed new insulating materials with higher dielectric characteristics and have redesigned the ignition harness to increase creepage distances, and we have taken hurdle number two.

"We now have high enough manifold pressure, and the ignition system is operating, but our engine is still not operating efficiently, because the reduction in pressure has caused the gasoline in the tanks and fuel lines to vaporize, causing a loss of fuel and the formation of vapor locks within the lines. The design of tank and booster pumps takes care of these problems, and we have the engine running, but there are still more problems to come.

"The thin air at high levels is now found to give insufficient cooling, and the whole problem of heat transfer is opened. The research boys go to work again and redesign the cowl flaps, oil coolers, and the ducting around the cylinders. Others develop new materials which will withstand higher operating temperatures, and we at last have some of the engine problems pretty well in hand. Thus it will be seen that simultaneous research in all fields is necessary to keep our scientific progress from faltering. One missing link in the chain of development may well hold up an entire program.

"So far we have only considered powerplant problems, but the human mechanism must be provided for as well. Man, like an engine, loses efficiency as the atmospheric pressure about him is reduced. To keep up the human manifold pressure, to use a simile, pressurized cabins were designed for the *B*-29. A pressure cabin may be used in one of two ways. It may be used to eliminate the need of wearing oxygen masks on long missions by maintaining a simulated altitude below 12,000 feet, or it may be used to prevent bends by maintaining a simulated altitude below 30,000 feet. The *B*-29 may be operated with a pressure differential up to 6.5 pounds per square inch. This will permit operation up to 30,000 feet while maintaining an 8,000-foot cabin altitude.

"There were originally many fears about the use of pressurized cabins. It was thought that, if shellfire penetrated the pressurized area, the sudden drop in pressure would cause serious injury to the air crew. Some even contended that a man's eyes might pop right out of his head. However, before new equipment of any sort is installed in an Army airplane, it is subjected to tests as rigid as those of the airplane itself.

"The aeromedical laboratory of the engineering division at Wright Field was called upon to make conclusive tests on explosive decompression, as this phenomenon of suddenly reduced atmospheric pressure is called. A mock-up cabin was equipped with an oxygen system, a communication system, and a time-pressure recorder designed to make an accurate time tracing of rapid pressure changes. To make sure that the record would be complete, high-speed motion-picture cameras were also installed.

"The cabin was placed in a high-altitude chamber, such as is normally used to test the effects of high-altitude flight on personnel. A volunteer entered the cabin, and this very exciting simulated flight was begun. Pressure was maintained within the cabin equal to that existing at approximately 10,000 feet. whereas the pressure outside the cabin was reduced to that existing at an altitude of 35,000 feet. By means of doors with heavy paper apertures of different sizes, it was possible to puncture the cabin suddenly and thus reproduce the condition of explosive decompression in combat flight. This first test was highly successful, and the same test was afterwards performed more than 150 times (on different people), and there were never any bad effects.

"The pressure differential here was the same as that used in a bomber, 6.55 pounds per square inch. The decompression rate (87 pounds per second) was the same as would be produced if a pressure cabin of 1,000-cubic-foot volume was ruptured with a $5^1/_2$-foot-diameter hole. No ill effects were observed on any of the subjects. There were no latent symptoms. At the moment of decompression the subjects experienced a sense of inflation of the chest and abdomen. They were able to put on their oxygen masks and to unscrew the bolts on the cabin door, a fair indication that a pilot would be able to fly his plane to a safer level if his pressure cabin should suddenly leak.

"Pressurized cabins are now taken as a matter of course by the boys in the *B*-29's. Pressurization is considered a normal part of the airplane. One *B*-29 crew, flying across The Hump from India to China, hauling critical supplies, had a failure in one of the scanning blisters. A quick-witted gunner thrust a seat cushion into the hole and the flight was completed successfully without further event, and without loss of cabin pressure. In fact, they were so busy that they made several flights before replacing the blister.

"Placing the men in a pressurized cabin did not solve all the problems. The turrets and guns had to be operated. It was impractical to pressurize the entire fuselage, and so we had a choice of building pressurized cabins for each gunner or to build a large central cabin and design a remote fire-control system.

The General Electric Company started a development of three elements that now compose the system, years before the war. They then had to correlate those three developments into a remote fire control system.

"We chose the latter, because it gave the gunner better visibility, more comfort, and more protection from enemy fire. The system was designed to do more than remotely operate the guns, however. The system includes the automatic correction for altitude, temperature, ballistic characteristics of the ammunition, and the speed of the *B*-29 as well as that of the attacking planes. These factors are all automatically determined by the computer during tracking, and instantaneous and proper adjustment is made in the aim of the guns. Until recently there was a legitimate question as to whether one could actually shoot down attacking fighters with such remotely controlled armament. Well, that was until recently. Headquarters communiques from the combat areas seem to show that it is not only possible, but that the fire-control system is working out even better than we had hoped."

AVIATION'S ENGINE DEVELOPMENT

Now, let us turn to aviation's engine development for a moment. What I have to say is not at all intended to be critical of another great American industry. It merely is intended to indicate that one who is not skilled in a specialized field can easily underrate the problems of that field when entering it. If you turn back to certain publications, newspapers, trade magazines, and other vehicles for the dissemination of popular information in this country, you will recall that about 1940 the automotive industry was making great claims of what it was going to do in the production of new aviation engines to revolutionize this industry.

That was going to be brought about by adherence to automotive principles and experience, and, of course, it was with the idea of winning the war. One organization published some pictures of its engines which were of a new type, and it was stated that there were many new principles involved in them. To my best knowledge, these engines have yet to fly.

In 1944 another great automotive company started the design of what to them was a revolutionary large engine. That engine is yet to make its first flight and is now two-thirds the horsepower of the equivalent large engines of the old-line aircraft-engine manufacturers. I bring that out, not to criticize a great industry that has done so much in the production field to win this war, but to caution people who underrate the experience required in research and from skilled personnel who must maintain continuity of technical experience in any particular field.

One may be the greatest electrical engineer in the world, but he might have quite a bit of difficulty in building highways in the civil-engineering field. I do not think that the problems of development of highly diversified equipment are as far apart as this example, but the old saying is that every man should "stick to his last." Perhaps that is too general to be a fair statement. There have been contributions made by the automotive industry to the technique of aircraft and engine production, particularly, through the adaptation of some of their specialized processes to the aircraft field.

We owe a tremendous debt to the automotive industry, but had we depended upon that industry's aircraft production—no matter how extensive their laboratories, their technicians, or their resources—it is doubtful that we would be anywhere near where we are today. However, if the aircraft industry had attempted to build automobiles, the shoe would be on the other foot, and the end result the same.

As to aviation-engine development, I was privileged to make a study in Britain in 1942 of British experience and found that responsible officials of the Ministry of Aircraft Production would not make a statement that any major aircraft engine in Britain had been developed in less than six years. In this country, we have records of approximately five years that I know of personally. I have heard claims of less than that, but I do not know of any such instances.

Thus, the problem of aircraft engines, for instance the Allison, is very interesting. That engine started in approximately 1930, and it had ten years of development experience before the war began. In our own case our Ranger engine had been started in 1928 and had gone through successive developments before it became a production engine for the war in 1941 and 1942.

In airplanes the Douglas *B*-19 is a typical case of courageous development work. This is the huge Douglas bomber you probably saw illustrated before the war, the tail surface of which looked as high as a five-story building. It probably is the largest flying laboratory ever built in the history of the world. Only one was ever constructed. It cost many millions of dollars. This *B*-19 is a flying laboratory in which priceless experience has been gained, out of which the heavy bombers of today have grown.

IMPROVEMENTS IN ARMAMENTS

Turning to the field of armaments, we have the interesting question of guns. Our best medium-caliber guns, particularly in the antiaircraft field, stem from European developments. The reason for this is the United States has never had an equivalent ordnance industry or comparable ordnance development during peacetime. We have had to draw on foreign industry since we have not had continued research of our own. I am not undervaluing the work of our ordnance departments. They did not have the funds. There was no private industry and no market for such a product. Thus it was the foreign ordnance firms that sold their wares in international trade on whom we had to draw for much of our ordnance experience for this war. We have developed some unusually fine ordnance, but we must not forget, in our patriotic American way, that there are other people in the world at work and that frequently we absorb their ideas without intending to appropriate them.

The question of jet engines is one that right now has a great deal of public interest. Like the helicopter of a few years ago it has been made to appear out of focus. The helicopter of a few years ago was going to take off in your backyard and land at your golf club. It was going to be the postwar personal airplane. I do not think it had any limits in the minds of people who drew pictures for popular magazines. Today it has settled down into what it should be—a useful piece of aircraft equipment with new performance characteristics not found in other types, supplementing the other types, enlarging the field, but not displacing the field.

At this date, it is fair to say that jet engines should be so considered. Fuel economy is still a very definite problem in jet engines. There is a new German airplane, I believe, the Messerschmitt 163, a single-engine intercepter rocket jet job. It goes at a speed of about 500 miles an hour and has a perfectly amazing rate of climb beyond anything that we have at the moment, and some very potentially unpleasant implications for us.

That particular airplane, however, is confined to what we call airport operation. It must work very close to its home airport. It drops its undercarriage the minute it takes off, and then shoots up like a rocket, and will go through a bomber formation at a speed so great that even fire control is not too effective against it. It does not maneuver. It just goes on its way.

When it penetrates above the bomber formation, it pauses, turns off the propulsion machinery, and cruises around as long as it can by gliding, waiting for a victim to appear. Soon it has exhausted its fuel and lands wherever it can. It cannot always go back home and frequently must be trucked back to its airport or home base.

Then there is another two-engine Messerschmitt, I believe it is the *Me* 262, which is a jet job that the Germans have produced. It has range, and it has more of the characteristics of an ordinary airplane. It is assumed to have 550-mile-an-hour performance. It too has limitations, but there is no use denying the fact that the Germans have been first in the jet field.

Yes, we have jet airplanes, but let us not fool ourselves. We are late with them. The Bell airplane—the first American one to fly—today is designated a trainer. The second one which will fly is the *P*-80—now in production. But the Germans have jet planes in their squadrons. They have been seeing service for some time.

There are other cases where we have been behind the enemy. We do not like to admit it, but he has been at work with continued research in the art of war while we have been going about our peaceful way with refrigerators and radios.

Let us take radar. Radar presumably was conceived at the Anacostia Station of the Naval Research Laboratory by two scientists in Naval employ. At least the principles were developed there. But, if I am not mistaken, the British were the first to utilize radar in a major way during the battle of Britain. By means of radar, 700 of their fighters stood off 2,400 German attacking craft and annihilated such a high percentage of them that the battle of Britain was won as a defensive battle by Britain.

The technique was simple. Radar located the enemy before he had approached the shores of Britain. Radar determined roughly the type of airplane and their quantity so that the high command in Britain was able to have its airplanes off the ground and in the air at a predetermined spot where the German airplanes were likely to arrive. The Germans instead of annihilating the British aircraft on the ground, as they had done the Polish, found Spitfires and Hurricanes in the air ready to do battle. This they did so effectively that they won that phase of the air war.

ENEMY EXPERIENCE CORROBORATES ALLIES

In defensive warfare the German airplanes were defective. They were defective because of a German policy—not because of a lack of ability in the technical field. That policy was to design their airplanes for offensive purposes essentially as air co-operative ground support. So, the British took advantage of this weakness with the superior offensive performance of their Spitfires and Hurricanes and took a frightful toll of the Germans. It took Germany several years to reorient her policy and produce airplanes in the attack field that anywhere near approached those of the British.

You find all through these examples one single theme. *There is no substitute for continued research and development and evaluation.*

Examples in many other fields could be mentioned. Frankly, we were not up with our enemies in torpedoes. There may be some Naval people who would deny that statement, but it is not my own. It comes from persons who are considered competent in these fields. And again it had been lack of funds for continued peacetime research and development.

You all know there is much argument concerning whether our tanks are better than German tanks. Our tanks are mobile, fast. The German tanks are ponderous, heavily armored, and heavily gunned. For some types of operation, the German tank is definitely superior. For some types of operation our tanks are superior. We followed divergent courses, just as was the case with German and British aircraft. Peacetime development and military study and evaluation could have solved this problem and provided us with a wider choice of tanks.

Let us turn to another country for an example to demonstrate our thesis. In Italy, an impoverished nation founded the city of Gidonia, which was devoted entirely to aviation research. They had more wind tunnels located there than we had in the United States. At the same time the German *DVL* Laboratories and similar institutions so far surpassed our NACA and the sum total of other American laboratories that it is fair to say we were probably not much more than a third or a fourth as great in the field of research, quantitatively speaking.

Fortunately for the United States, for some years our NACA had led the world, and we lived on that momentum. But time was running out, and, as I have said earlier we were a second-rate air power because of lack of funds for continued development and research, relative to what our aggressive enemies were spending.

I do not know much about Japan, but we undervaluated Japan seriously. We called them "copycats." If you examine the instruments, the engines, and structures of Jap aircraft that have been shot down or captured and brought to our laboratories for dissection and study, you will dispose of that idea. They did what any nation would have done in the initial stages. They borrowed from every country in the world—French licenses, British licenses, German and American licenses. For example, out of all of that pooled information they frequently built an engine that had American-type parts and German-type parts and French-type parts, all in the same unit. They borrowed from any source available, but they did not stop there. They built laboratories and went to work and produced, in some fields, devices that are superior to anything we happen to have in the corresponding field.

We must not underrate or undervalue the Japs. They are doing original work and under the desperate conditions in which they find themselves today as a nation, I think you will find continued and rapid progress on their part.

You all remember the attack on the cruiser *Savannah* by a guided missile. You may recall that it took us quite by surprise. The Germans were using forms of guided missiles, controlled by radio or by other means.

Similarly, the robot-bomb development in Germany is now ten years old. Had it been ready for service and in use one year earlier, some authorities believe that the course of this war might have been drastically changed. That is a pretty close margin, isn't it?

At this late date we have copied the German robot bomb, and I presume that you soon will hear about ours being superior to theirs. We often have to do what the Japs did—copy something, and set out to improve it. I have no doubt we will improve it. But let us remember we borrowed it from the Germans. I might say we borrowed it as an engineer traces a blueprint. Of course, there are newer types of robot bombs under development.

AIR WAR BLAZES RESEARCH TRAILS

General Arnold in a closed meeting for the aircraft industry last fall said that two great developments had come out of the air war—the ability to fight in the air without pilots or human crew, and the mass use of air-borne troops. Each development requires completely new engineering material for which there is no past background or pattern.

To illustrate the problem, our company, at the request of the Quartermaster Corps, undertook to redesign a refrigerated truck. From memory it weighed approximately 15,500 pounds, exclusive of the motive-power unit. When we got through it weighed a little over 7,000 pounds, carried the same load, performed the same duty, but not with the same construction. We used airplane methods of design, whereas the truck had been built in accordance with automotive methods. If you figure a truck empty weighs over 15,000 pounds, and you have to take it loaded through the muddy roads of Italy and over bridges not made for more than donkey carts, you can see the problems to be solved in moving a mechanized army up to the front.

In utilizing air-borne troops, this problem is more serious. You cannot afford to take the kind of guns and gun mounts in by air as you do over the ground. And so it seems perfectly reasonable to assume that much of our ordnance, much of our matériel, ultimately will have to be redesigned for air-borne operation.

Our Army now has field kitchens that can be flown in by air, designed for light weight and compactness. They also have equivalent field hospitals, X-ray apparatus, field bakeries, field ice-cream plants, as well as mobile trucks and other troop matériel.

Aircraft, as well as ordnance, is going to have to be designed for that type of operation. Airplanes are going to have to be more like cargo ships and less like *Queen Marys*.

ELECTRICAL ENGINEER IN VITAL ROLE

In all of these problems the role of the electrical engineer is vital. Colonel Holliday at Wright Field, in charge of the electrical-engineering section in General Carroll's engineering group, had been discussing this problem with me. I needed considerable help, and he supplied it in admirable fashion. He stated:

"In general the electrical industry has done much for the war effort of the Army Air Forces. Proof of this lies in the fact that no tactical airplane can accomplish its military mission unless its electric system is functioning efficiently and reliably. For example, a bombardment airplane cannot navigate to its objective, operate the bombsight, drop its bombs, or fight off enemy fighters, unless the electric system is operating.

"Much of this has been due to the fact that the electrical industry has increased the power available from engine-driven generators to an almost unbelievable extent without asking for any increase in space and little increase in weight. In five years the output has been increased 16-fold with an increase of less than 50 per cent in weight and no increase in the allowable dimensions on the engine-accessories section. Similar but not so outstanding increases in performance have been made in electric motors. However, much remains to be done.

"One exception in which the electrical engineer has not produced an equivalent answer lies in the wheel brake. There has been some demand for an electrically actuated wheel brake which would make it possible to produce an 'all-electric' airplane.

"Electrical engineers should further study their designs to improve reliability. Life of many electric accessories is altogether too short. Further, some electric accessories on failure become more of a hazard than the simple omission of an accessory. It is essential that potential failures in electric apparatus be minimized to insure that the device will be safe in the event of failure.

"Continuous effort must be expended to reduce the weight of electric accessories. As airplanes increase in size and range, the importance of weight becomes still greater.

"Because many members of the electrical industry operate with a small financial investment, they also produce equipment to poor standards of performance. The industry itself should, by means of its own organizations, combine to eliminate such production, because failure of one manufacturer to produce satisfactory equipment will be an indictment on all.

"Electric accessories which will be needed in the future include the wheel brake already mentioned, automatic controls, motor-driven actuators, an electric system of cabin pressurization, better instrument lighting, improved external lighting equipment particularly from the aerodynamic viewpoint, air-conditioning equipment, improved cabin lighting, and other accessories which go with luxurious air travel. The field of automatic controls has hardly been touched. The airplane has become such a complicated machine that no one individual can possibly know enough to watch continuously performance of various parts and prevent operation under a critical condition, thereby risking failure. The electric system can take over this task and do it easily.

"Motor-driven actuators to do the same work as hydraulic actuators are badly needed. Most of the actuators now available are too complicated and heavy. Component parts do not have sufficient reliability. Anything to improve this situation will be welcomed by the aircraft industry.

"Aircraft lighting for too long has been solved with the simplest designs. The time has come to study lighting seriously, not only at the instrument panel, but also in passenger compartments, to produce levels of illumination and arrangements of lighting which will lead to the utmost comfort."

WEIGHT-SAVING MATERIALS

We also discussed the use of aluminum wires and cables in aircraft to save weight. I had been deeply interested in that subject during my period in the wire and cable industry. There are large savings in weight to be realized in aircraft by the use of aluminum for conductors where properly applied. For instance, you would defeat your objective if you had to put them in steel conduits because of their larger diameter. Just why they have been so long in coming I do not understand. It may be due to the inability to work up proper electrical standards and to have them adopted by the services who must operate on the basis of procurement specifications. If the electrical industry does not produce the specifications and have them approved, they cannot be specified for procurement.

ELECTRICAL PROBLEMS

In a discussion I had with General Carroll he emphasized the importance of electrical engineering in aircraft somewhat as follows:

All airplanes are becoming flying power plants. The fire control is obviously an electrical problem. In a *B*-29, for instance, there are 20 different radio and radar sets. Flight controls are electric. The bombsights and bomb racks are electrically operated. The landing gear should be operated electrically. Electrically heated blankets and corresponding outlets must be provided. The flight personnel are encased in electrically heated suits. The main-engine-driven generators must be of high-altitude types and subject to the limitations of weight and space already mentioned.

Auxiliary power plants are now required in order to furnish power on the ground, because batteries are too heavy. A-c systems of higher voltage are needed in the modern large airplanes. There are millions and millions of feet of power wiring used, and weight is important. High-voltage a-c procedure should greatly eliminate such weight.

Today we still use the low-voltage d-c systems. Instruments are largely electric. A number of electronic applications are too secret to list. Our propellers often operate by electric mechanisms. At time we have ignition problems of a serious character at high altitude. These, he stated, are just a few of the applications and problems.

Interesting is the fact that, in *B*-29 operating squadrons based in the fighting areas, it is now necessary to have a highly experienced electrical engineer stationed with each squadron.

So, you see the electrical engineer should play, and is playing, an extremely important role. We need continued peacetime research and development if our Nation is to avoid disastrous wars in the future.

E. F. W. Alexanderson—1944 Edison Medalist

In recognition of his "outstanding inventions and developments in the radio, transportation, marine, and power fields," Ernst F. W. Alexanderson was awarded the AIEE Edison Medal for 1944. The presentation was made at a joint meeting of AIEE and the Institute of Radio Engineers during the 1945 AIEE winter technical meeting.

THE EDISON MEDAL, highest honor of AIEE, was awarded for 1944 to Ernst F. W. Alexanderson (F '20) consulting engineer with General Electric Company, Schenectady, N. Y., at a joint session of AIEE and the Institute of Radio Engineers, January 24, during the 1945 AIEE winter technical meeting in New York, N. Y. Presentation was made by C. A. Powel, AIEE president, who stated that the honor was conferred upon Doctor Alexanderson in recognition of his "outstanding inventions and developments in the radio, transportation, marine, and power fields."

Karl T. Compton, chairman of the Edison Medal committee, and president of Massachusetts Institute of Technology, Cambridge, Mass., outlined the history of the medal which was established by a group of associates and friends of Thomas Edison to serve as "an honorable incentive to scientists, engineers, and artisans, to maintain by their works the high standard of accomplishment" set by Edison himself, and which has been awarded annually by the AIEE, with two exceptions, since 1909.

The career of the medalist was narrated by R. C. Muir (F '36) vice-president of General Electric Company, Schenectady, N. Y., and long-time associate of Doctor Alexanderson. Inventer of the alternator which made the first radiobroadcast possible, Doctor Alexanderson holds some 300 patents in radiotelephony and telegraphy, television, motors, generators, power transmission, vacuum tubes for radio and power rectifiers, electric ship propulsion, and electric traction.

Full text of Doctor Muir's address and Doctor Alexanderson's response follows.

The 1944 Medalist

R. C. MUIR
FELLOW AIEE

Doctor Alexanderson during all the time I have known him has always had some difficult problem to wrestle with, and fortunately he has been a very good wrestler. It was back in 1905 while testing a new kind of alternator that I first met him, and since that time his name has always been before me in connection with one new development or another.

The single-phase railway motor, the 100,000-cycle radio alternator, multiple-tuned antenna, selective tuning for radio receivers, facsimile broadcasting, thyratron exciter, thyratron control, thyratron motor, high-voltage d-c transmission, electric ship-propulsion control, and Amplidyne control are all mileposts along the path of engineering progress which have been erected by Doctor Alexanderson. He has been granted more than 300 patents on inventions which embrace a large part of the electrical field and which bespeak his ingenuity, versatility, and activity.

I once received a postal from a friend which started thus: "It is a bright crisp morning, and I am as full of pep as an Alexanderson alternator." He might have said that he was as full of pep as Doctor Alexanderson himself, and it would have conveyed the same meaning to me.

It is the human side of Doctor Alexanderson that is not so well known. Many people have the notion that someone who acquires great distinction in the field of art, science, ngineering, or invention, is not otherwise iormal and cannot be approached or alked to as we talk to an ordinary person. t is true that there are a few famous emperaments among the famous. But nost of the famous people I know, like Doctor Alexanderson, are human beings oo.

He loves people. Possibly his favorite port is sailing, a sport to be enjoyed with thers. Aside from giving a great many he enjoyment of a sail in his *Nordic* on ake George, he has taught others to sail, nd his enthusiasm has spread so that sailng races, in which he enthusiastically paricipates, are held each week on Lake George throughout the summer months. He likes to walk, to swim, to dance, to kate; he even plays bridge with enjoynent and some luck. He enjoys good nusic and does not mind taking part in a ousing song. As L. A. Hawkins, executive ngineer of the General Electric Company esearch laboratory has said: "Afloat or shore, Alexanderson is always a genial nd stimulating companion, while his traightforward character and his unafected good fellowship make him a lovable riend."

He loves to work with young people, nd they like to work under his guidance. To use his own words, "The relationship etween the older and the younger generaion should be one which is not characterzed as a boss and an assistant, but one of eamwork where the younger generation upplies the knowledge of the latest techical development and the older generaion contributes experience and imaginaion. The relationship is intimate and ersonal." These are his own words, and ny observation is that he carries out these rinciples wholeheartedly.

It undoubtedly has had much to do with eeping him young and alert. After 40 ears of engineering, he is still turning out nventions and stimulating his younger asociates to do likewise. An early associate vho has been granted 90 patents has told ne of the tremendous stimulation he reeived from Doctor Alexanderson. One f his younger associates has to his credit 4 patented inventions, and another 54.

In recent years one of his most important ontributions has been in connection with ower amplifiers and positioning-control rojects carried out largely by younger men nder his direction. Notable among these s his joint invention with his assistant, M. A. Edwards, of the Amplidyne, an rmature-reaction-excited and fully comensated type of d-c machine that is ctually a two-stage amplifier. This is the asis for the electronic control of turrets nd guns in our airplanes, for antiaircraft uns on land and aboard ships, for searchghts, antenna, and other applications vhere quick and accurate response and mplification of power is necessary. Forunately, it also has many applications in eacetime industry.

It has been my good fortune for many years to have Doctor Alexanderson discuss his new projects with me, and I have always had difficulty in following him. We agree on the objective and I usually understand the initial steps. I lose him quickly, however, as he hurdles the many problems on the way to the end result which he always seems to see quite clearly. My impression is that he has a powerful intuition which enables him to see through the problem clearly, and he just does not worry about the obstacles along the way. Probably that is one reason the young men like to work with him—they clear up the obstacles.

AIEE President C. A. Powel congratulates E. F. W. Alexanderson after the presentation of the Edison Medal

Doctor Alexanderson has had many honors bestowed upon him. In 1919 he received the Medal of Honor of the Institute of Radio Engineers, and in 1924, the Knighthood of the Polish Order of Polonia Restituta, and, in 1928, the John Ericsson Medal. In 1934 he was elected to the Royal Academy of Sweden, the body which bestows the Nobel Prizes in Sweden. In 1940 his name was listed in the Hall of Fame at the World's Fair for foreign-born citizens who had contributed most to the United States. In August 1944 Doctor Alexanderson was awarded the Cedergren Gold Medal of the Royal Technical University of Stockholm in recognition as a writer of prominence in electrotechnics.

He is a Fellow of the American Institute of Electrical Engineers, a member and past president of the Institute of Radio Engineers, and a charter member of the Institute of the Aeronautical Sciences. He has a long record of service in these technical societies.

He has honorary degrees of doctor of science from Union College, Schenectady, and doctor of philosophy from the University of Uppsala, Sweden.

As a close friend, admirer, and associate, I am delighted that the committee has chosen Doctor Alexanderson for this highest of all honors in the field of electrical engineering—the Edison Medal.

The Edison Tradition—A Challenge to Industry

E. F. W. ALEXANDERSON
FELLOW AIEE

I deeply appreciate the honor you have bestowed upon me in the award of the Edison Medal. However, in accepting it, I feel I do so in full recognition of the honor it symbolizes to the General Electric Company and the many engineers closely associated with me in my many years of work for this company.

I feel that in the acceptance of this medal we are also paying homage to the great inventer and the great American, Thomas A. Edison. In doing so we may give some thought to the place of invention in our social order. Invention must in this connection be given a broader meaning than the usual one. Here it should mean resourcefulness in dealing with new situations and eagerness to put new ideas to practical use. There are many times more inventions and inventers than there appear in the patent records. It is this great backlog of talent that is the strength of our

Nation and which has given the United States the reputation of a nation of inventers. As a symbol of American inventiveness, still stands out alone the name of Edison, the creator of the electrical industry which has more than anything put its stamp on life and society since the beginning of the century. As America was seen from across the ocean, distance lent even greater enchantment, and to the name of Edison was added the name of Steinmetz, the great electrical engineer. Attracted by the fame of these names, there was a pilgrimage of electrical students from Sweden to the United States at the turn of the century, and I was among them.

Thus I soon found myself working in Schenectady. It gives me a great satisfaction to be able to say now after more than 40 years that I had not been chasing a rainbow but that I found almost immediately in the United States and in General Electric Company, all that I had hoped for in inspiration, opportunity, and friendly guidance. While I was still a student engineer I wished to try out some new ideas. Machinery was made available, and our chief engineer, E. W. Rice, who is remembered with admiration by all who knew him, found time to discuss the project and witness the tests. I also found that Doctor Steinmetz, whose reputation brought me to the United States and to Schenectady, was always accessible for discussion of new ideas.

This was the spirit I had hoped to find in America and the reason why I came here to stay, and not for a youthful adventure as my family in Sweden had hoped it would be. Some years later when it was my engineering assignment to design a-c railway motors, I was allowed to experiment at my own initiative with high-frequency alternators and other devices intended for telephoning across the ocean. The appropriations for this experimentation were approved by Mr. Rice personally and the objective was eventually realized.

This is just an example of the spirit of the leading industrial institutions. Similar testimony might be given for other electrical manufacturers and other industries. Much original work of high merit is done by independent inventers, but there are some lines of work which due to their character can be undertaken only by large industries. The typical American spirit of optimism towards invention prevailed largely until the depression in the 1930's. It was said then by many that we should have an inventers' holiday, because invention makes production so efficient that it creates unemployment. But then this war came, and the creative resources of industry were mobilized; scientists and teachers turned out by the thousands from the universities and have done a magnificent job of fighting the war with invention. But it is a paradox that it takes a war to permit this source of creative talent to function in its full and natural way. Some of our economists state convincingly, indeed much too convincingly, that the present pace of new development cannot continue because the Nation cannot afford to maintain it.

In a speech before the National Industrial Conference Board, 1944, Virgil Jordan made some impressive statements under the heading "Let Us Tell Them the Truth." I quote: "Never before have we been so self-conscious about postwar employment—war today is a public-works program turned upside down. That is why someone has said that war has become the main instrument of domestic policy, and, by a strange paradox, men pursue social or economic security by dropping high explosives on each other." He also quoted William James, the American philosopher, who racked his brains in the '90's to suggest what he called a moral equivalent of war and came out only with a sort of mid-Victorian version of WPA.

Quoting again from Mr. Jordan's speech: "Let us not pretend to them that for the first time in human history something has happened in America while they were gone that makes the words 'national planning' mean anything different than personal compulsion."

When viewed through these blue spectacles of the economist the world looks gloomy. Without questioning the soundness of the economic argument, many of us are inclined to feel that something has been left out, some social factor which perhaps does not belong in the realm of economics. If, on the other hand, we put on the rosy spectacles of the inventer, the world looks different. The creative talent is there. We have proved it during two wars. The engineers are eager to do their part in creating new industries. Conditions may after all not be so very different now from what they were in the early days of Edison. While William James racked his brains to find the moral equivalent of war, Edison had a different approach. He did something about it and founded the electrical industry. Then Marconi stepped in and started the radio industry. Is not this what the world needs—engineers who can create new industries? We cannot point to any one successor of Edison, but Edison's spirit is alive among all of us and is symbolized by the Edison Medal. This symbol and all it implies is held up as a guiding beacon, an object of faith for the engineering profession. It is also a challenge to the engineers of this generation, a challenge that we must accept and prove that our faith is the kind that can move mountains. When Edison brought out his system of electric lighting, it was an expensive luxury. But he was not discouraged by the fact that it could not compete in economy with gas lighting. He and his backers had the faith and courage to push his dream to realization and make out of it what he saw in his mind's eye and what we now know to be a fact.

Marconi had to come to England and America to get financial support for his invention, but nobody at that time imagined the magnitude of the industry tha would develop from it. Let us hope tha there will be in the future the same kind of willingness to take financial risks and that the history of the age of Edison wil repeat itself. What right have we to say at this time that science and invention have been exhausted and that we are no longer able to create new industries? If the only work that we can see ahead of us is to do more efficiently and in greater volume the things we know how to do now, then we must also accept the sad but logical conclusions of the economists. Perhaps thousands of years from now science and invention will be exhausted and our civilization will be superseded by another, but the knowledge of engineering is only a couple of hundred years old, and we are at the apex of technical evolution, and with a man power of creative talent greater than any that has ever been assembled. This creative man power must not be held down to routine work lest the worst predictions will come true, and prophets of gloom prove right after all!

Science has made enormous progress during the war and has given us a wealth of new ideas to work with. In electrica engineering alone we can see a number o great possibilities. Edison gave us electric light; but some day we will be heating a well as cooling our houses by electric power; ships will be propelled with electric motors fed from coal-burning gas turbines our railroads will be electrified, utilizing our undeveloped resources of waterpower

Looking still further ahead, we may hope for the discovery of some entirely new sources of energy which will extend the use of electric power. Electronics, the new branch of the electrical industry, will be put to work to solve these problems There are so many applications of electronics in both power and radio that I shall not even attempt to enumerate them. A new generation of electronic engineering has grown up and is ready and eager to turn from war work to peace work. They will revitalize the electrical industry with new experience, new tools, and new ideas.

Inventions will not solve all our social problems, but they will be an important factor as they have been in the past Engineering contributes to the future. I the engineer really believes in the value o his contribution, the financier will believ in it too and support him as he has done i the past.

The Edison Medal is a symbol and challenge that this shall come to pass an that the next generation of engineers sha live up to the traditions of Edison, Wes inghouse, and Marconi. With this fait and hope I wish to express my deep-fe appreciation of the honor which has bee conferred upon me and the company whic I represent.

Electronics of the Mass Spectrometer

JOHN A. HIPPLE DON J. GROVE W. M. HICKAM

The value of the mass spectrometer as an instrument for the quantitative and qualitative measurement of the components of gaseous mixtures is enhanced by a recording system which combines speed of response, accuracy, and extensive range. These have been attained by incorporating an automatic speed-up between peaks, an amplifier for currents as low as 10^{-14} ampere, an automatic range changer for off-scale peaks, and a nonlinear scale to overcome the limitations of a ten-inch chart.

THE suddenly developed need for high-quality aviation gasoline, synthetic rubber, explosives, and other important materials having a vital relation to the success of the war effort gave impetus to the task of finding improved means for quickly and accurately determining the purity of constituents forming a part of these products. For making these determinations such methods as fractional distillation and infrared and ultraviolet absorption have been employed with varying degrees of success, often in conjunction with one another. No single method provides the complete solution of the problem for all possess shortcomings, which has accelerated the search for other methods, particularly one that will facilitate making analyses of complex hydrocarbon mixtures. The mass spectrometer is a new and valuable method in the analysis of such problems.

In addition to its value in determining the purity of the compounds mentioned, the mass spectrometer has other important uses, and it might be well to summarize some of them here:

1. In all tracer work where stable isotopes are used (this method is practically the only available one).
2. For analysis of small traces of gas in a mixture.
3. In analyses where only a small sample of gas is available, as in the analysis of the residual gases in sealed-off electronic tubes.
4. In analyses requiring the continuous indication of changing composition during a process, as in the gas atmosphere of an annealing furnace.

The mass spectrometer, as the name implies, is an instrument in which ion streams of different masses can be separated and measured in a manner that permits both qualitative and quantitative measurement of the components of a gas mixture. It is essentially a high-vacuum tube into which the gas to be analyzed is admitted and ionized. By closely controlled electric and magnetic fields, the ions are caused to move through the tube so that each stream of ions of different mass can be focused successively on an exit slit at the end of the tube where they impinge upon a plate and give up their charge. This charge or current is amplified and measured by electric instruments. From the characteristics of these electrical readings the exact composition of the gas mixture is readily obtainable.

Figure 1 is a schematic illustration of one type of mass-spectrometer tube, which will serve to illustrate the essential principles involved in mass spectrometers used today for routine analytical work. The tube is evacuated continuously by means of a diffusion pump, and the sample flows through the ion source continuously during the analysis. Electrons emitted from the filament are accelerated through the slits in the electron gun formed by plates 1 and 2, and the current in this electron beam is measured on electrode 3. The ions formed by the impact of the electrons on the gas molecules in the region below plate 4 are repelled by the slight positive voltage on this plate through the slit in 2. These ions, emerging from the slit in 2, are accelerated to plate 5 by the fairly high potential difference between 2 and 5. Conventionally, electrode 2 is of the order of 1,000 volts positive with respect to plate 5, which is at ground potential. The ions now pass into the analyzer portion of the tube, the internal surface of which is grounded to provide an effective electrostatic shield for the beam. The curved portion of the analyzer is situated between the pole pieces of the electromagnet; the field from this electromagnet deflects the ion beam, as indicated by the arrows. The radius of curvature of the ions is given by the following formula:

$$r^2 = \frac{m}{e}\,\frac{VC^2}{150\,H^2} \qquad (1)$$

r = radius in centimeters
m = mass in grams
e = charge in electrostatic units
V = accelerating voltage in volts
C = velocity of light in centimeters per second
H = field strength in oersteds

By appropriate adjustment of the fields, an ion of any desired m/e may be focused on the exit slit, 6, passing through this slit to the ion collector plate, 7. In order that the focus of the ion beam on the exit slit may be maintained, it is necessary that the ion accelerating voltage and the deflecting magnetic field be very carefully regulated. For an instrument designed to handle the usual analytical problems, the ion accelerating voltage should be maintained constant to at least one part in several thousand, and, as the magnetic field appears as a square term in equation 1, the regulation required for this is twice

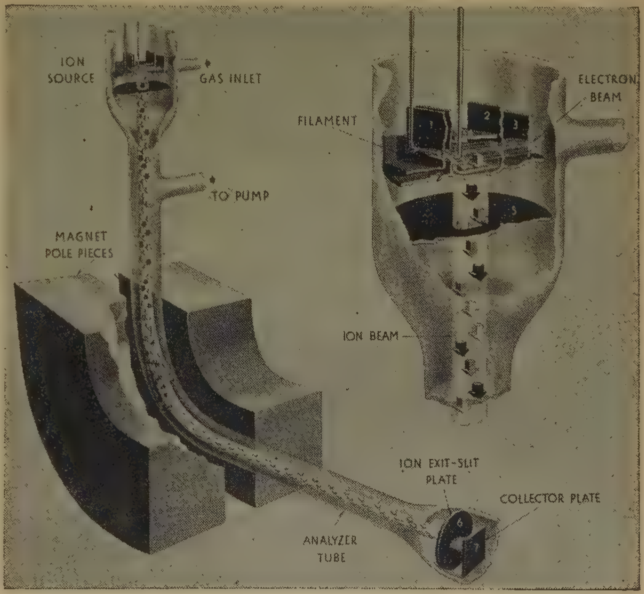

Figure 1. Schematic drawing of one type of mass-spectrometer tube used for routine analytical work

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Essential substance of a paper presented at the National Electronics Conference, Chicago, Ill., October 5–7, 1944.

John A. Hipple, Don J. Grove, and **W. M. Hickam** are attached to the staff of the research laboratories of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

The authors express appreciation for the work of their associates who have contributed to the development of the mass spectrometer.

as great. The careful control required on the power supplies providing these fields may be obtained by means of conventional electronic regulators. Since the magnet employed with a tube using a deflection of 90 degrees is fairly small, it may be energized with a regulator of rather low power output. The maximum magnetic field required may be obtained with 110 milliamperes. The interrelations of the various components in the instrument are shown schematically in Figure 2, and the connections shown in Figure 3 provide the necessary correlation of the electron and ion beams.

Analysis of the amount of oxygen and nitrogen in air illustrates the operation of the mass spectrometer. Oxygen and nitrogen in precisely measured proportions are prepared and allowed to flow through the mass-spectrometer tube as indicated in Figure 2. Ions of nitrogen and oxygen enter the analyzer from the ion source. The fields are adjusted so that the nitrogen mass 28 is focused on the exit slit of the mass spectrometer, and the current is measured. Since the oxygen mass 32 is heavier, it is not deflected so much by the magnetic field and is lost on the grounded interior of the analyzer. A readjustment of the fields permits the current corresponding to mass 32 to pass through the exit slit and be measured. The instrument thus is calibrated for nitrogen and oxygen in any proportions, and the quantitative determination of the composition of air passing through the mass spectrometer can be secured.

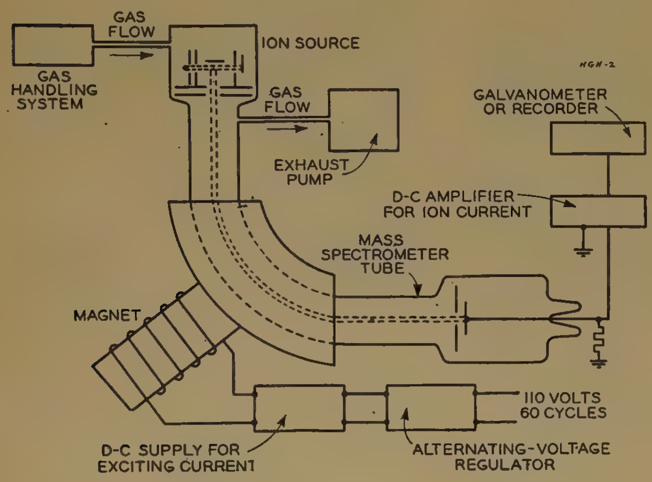


Figure 2. Detailed schematic diagram of mass spectrometer showing interrelation of components

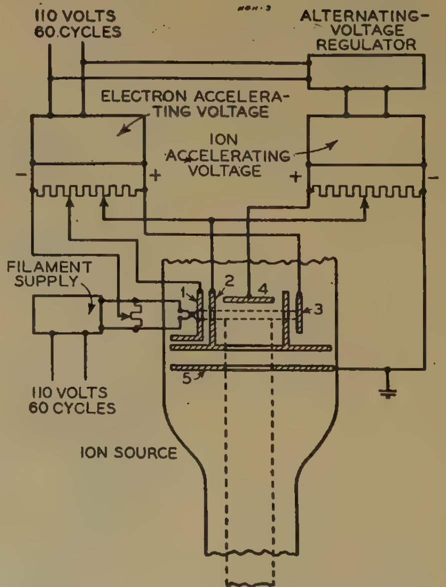


Figure 3. Detailed schematic diagram of ion source showing interrelation of components

As previously described, the currents reaching the collector plate, 7, corresponding to the various masses are carefully measured. During this scanning of the spectrum it is essential that the electron current to plate 3 be kept very constant. This is done by using the current to plate 3 as a signal for controlling the heating current in the filament. The circuit used for this control is similar to that used for the control of the emission in ionization gauges.[1] Figure 4 shows the constancy of this electron current over a considerable period of time.

For effective use of the mass spectrometer a fast recording system is a necessity. The problem is that of obtaining a large amount of data in a very short time and accurately measuring currents which differ greatly in magnitude. A pen recording system was believed to be desirable, if it could meet these requirements. A brief review of recording systems which heretofore have been applied to the mass spectrometer would include primarily only those using a combination of light beam, mirror galvanometer, and photographic paper. Bleakney, Smith, Lozier, and Smith[2] have described a recording system of this general type for use in studies of the fundamental processes involved in the dissociation of molecules by electron impact. This was a dual system which recorded the ion current and electron current simultaneously, since no attempt was made to monitor the latter. A very wide chart was used in order that a considerable range of ion currents could be covered. The system was slow, since in this application high speed was of minor importance, and in order to record with a line of uniform density the intensity of the galvanometer light was increased manually when the spot moved rapidly across the chart. Washburn, Wiley, and Rock[3] have described a fast recording system employing the photographic method with four galvanometers of different sensitivities to span the range required.

A pen recording system has been tried using the same setup as required for the photographic method but with the replacement of the photographic detector by photoelectric cells mounted on a motor-driven carriage carrying a pen which follows the deflections of the light beam across a strip chart.[4] This method satisfactorily eliminated the photographic film, but the speed of response was too slow for application to the mass spectrometer, and the problem of extending the range was a difficult one.

The Speedomax recorder of the Leeds and Northrup Company has been made the basis of the recording system now to be described.[5] That recorder has lent itself nicely to adaptations for obtaining the speed of response, accuracy, and range mentioned earlier.

In order that the spectrum of masses may be swept across the exit slit of the mass-spectrometer tube and reach the ion collector plate, 7, of Figure 1, either the ion accelerating voltage V between plates 2 and 5 or the magnetic field must be varied continuously with the chart drive on the recorder. The question of which one of these is to be varied is a determining factor in the over-all design of the instrument. A consideration of equation 1 will show that, if the ion voltage be varied, the voltage range required will be very great to permit the scanning of a wide span of masses. Thus for a fixed magnetic field the equation involved is

$$\text{Mass} \times \text{voltage} = \text{constant} \qquad (2)$$

If mass 10 be focused on the entrance slit with 6,000 volts, it will require 600 volts for mass 100. This means that, in order to scan continuously through this range, it would be necessary to have 6,000 volts available, and the instrument would have to be designed and insulated for this high voltage. Furthermore, unless very much greater ion voltage is available, it would be necessary to shift the magnetic field to record below mass 10 and above mass 100. If the scanning be done by varying the magnetic field, the ion voltage may be kept fixed at 600 volts, and the entire mass range may be covered with a variation of the magnetic field alone. The mass spectrometer and its associated power supplies then may be designed for low-voltage operation.

The scanning circuit for the magnetic field is illustrated in Figure 5. With this circuit, the load on the regulated high-

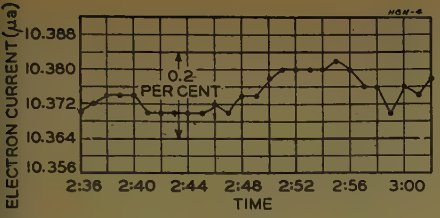


Figure 4. Plot of electron current as a function of time, indicating performance of electron-current regulator

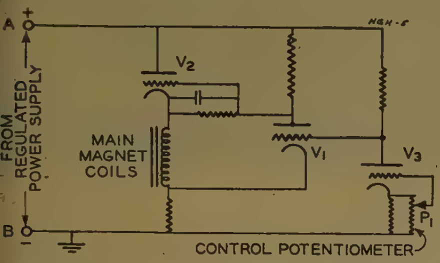
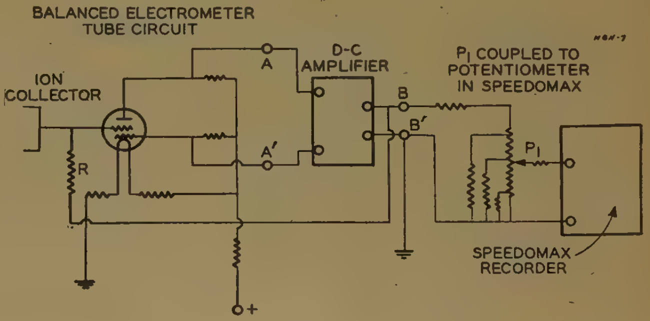


Figure 5. Magnet control circuit which makes possible a wide variation in magnet current with a single control, yet keeps nearly constant load on the power supply

voltage power supply may be kept constant within a few per cent, as the current through the coils of the magnet is varied from 10 to 110 milliamperes. The vacuum tubes V_1 and V_2 function as a series–parallel resistance control. As the scanning potentiometer P_1 is varied from one end to the other in a direction to decrease the current through the magnet, the plate-to-cathode resistance of V_1 decreases as that of V_2 increases, maintaining approximately a constant resistance between *A* and *B*. The potentiometer P_1 is mounted on the recorder and is driven by the same motor that drives the chart. In Figure 6 the recorder is shown with its top cover removed to illustrate this potentiometer.

To operate the recorder, an intermediate amplifier was required between the ion collector plate, 7, and the recorder input terminals, since the current to be measured could be as low as 10^{-14} ampere. The essential principles of the amplifier are shown schematically in Figure 7. The first stage is the conventional balanced circuit used with electrometer-tube amplifiers.[6] A balanced circuit of some kind is necessary in this first stage, because the voltage gain is actually less than one through the electrometer tube. This is followed by a high-gain d-c amplifier providing an output to the recorder at *B-B′*. By connecting point *B* to the bottom of the input resistor *R*, 100 per cent inverse feedback is obtained, so that the over-all voltage gain is unity and the input voltage at *B-B′* the same as the input voltage across the resistor *R*. This provides an amplifying system for the ion current which is faster than the recorder itself, which means that the recording time is limited only by the response time of the recorder. Since *R* is 2×10^{10} ohms, the input capacity to the electrometer tube would cause a very slow response time as the time constant is several seconds; however, with the feedback system just described, the speed required for fast recording may be obtained. As the Speedomax is itself a null instrument, the use of an amplifier with 100 per cent negative feedback in conjunction with the Speedomax gives us an essentially null method of measuring ion currents with attendant freedom from the problems of linearity associated with deflection methods. This complete amplifier is operated entirely from the 60-cycle power line.

Figure 7. Schematic diagram of the ion-current amplifier showing the various components and their relationships


NGH-7
BALANCED ELECTROMETER TUBE CIRCUIT
ION COLLECTOR
R
A
A′
D-C AMPLIFIER
B
B′
P1 COUPLED TO POTENTIOMETER IN SPEEDOMAX
P1
SPEEDOMAX RECORDER
+

In order to increase further the speed of recording the spectrum, an automatic speed-up between peaks has been incorporated. A spectrum of a mixture composed of ethane, ethylene, and neon shown in Figure 8 illustrates the functioning of this device. This spectrum has been retouched for reproduction because the red ink used in the recorder does not photograph well. When the pen is on the base line between peaks, the masses are scanned at high speed, and hence the chart is moving rapidly. As the pen deflects off the base line to trace a peak contour, it trips a switch at the region indicated on the diagram and automatically slows down the system to insure that the pen will have time to record accurately the top of the peak, as this is the only information required for the analysis. Just before the pen has returned to the base line after recording the top of the peak, it again crosses the speed-change line and automatically returns the system to its original high-speed scanning.

With the system just described it is possible to obtain a spectrum very rapidly, but the problem of accurately recording the wide range of ion currents on a ten-inch chart is unchanged. This has been solved by the addition of two features: the first is the incorporation of a nonlinear scale, and the second is an automatic range change.

Figure 7 illustrates the method of obtaining the nonlinear scale. The motor which drives the pen upscale is coupled to the movable contact on potentiometer P_1,

Figure 6. The scanning potentiometer which operates the magnet control circuit is shown in this view of the top of the Speedomax with the protecting cover removed

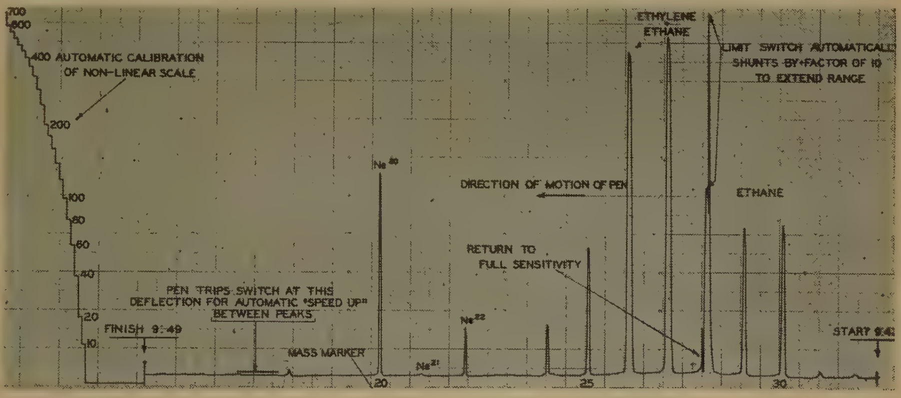


Figure 8. Spectrum of a mixture composed of ethane, ethylene, and neon illustrating the speed-up between peaks

This spectrum has been retouched to facilitate reproduction

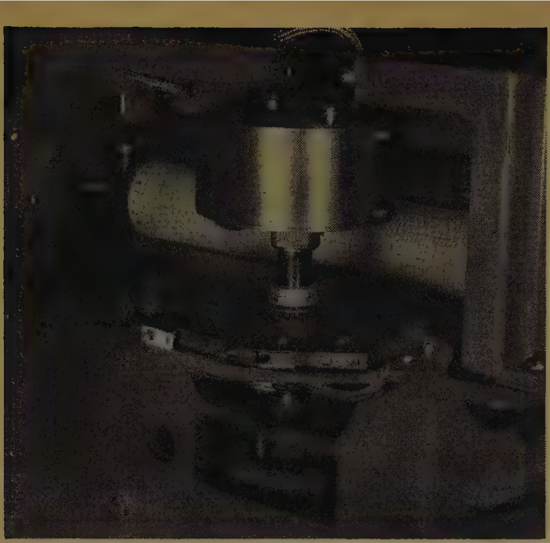


Figure 9 (left). The potentiometer P_1 of Figure 5 is shown in position in this view of the back of the pen and chart carriage

Figure 10 (right). The synchronous motor and pickup coil for the mass marker are shown to illustrate the position of the generator relative to the magnet gap

which shunts the input signal. Figure 9 shows this potentiometer mounted on the pen drive shaft. By means of resistances tapped into P_1 at various points, the distribution may be made approximately logarithmic from about a two-inch deflection to ten inches; and below two inches as it approaches zero it is approximately linear. Through the logarithmic range the peaks may be measured with a constant percentage accuracy over a range of 20 to 1. The chart is divided in tenths of an inch, and, when readings are made to a fifth of a division, the accuracy is better than one per cent. To convert the measured deflection on this nonlinear scale to actual peak height, it is necessary to know the scale calibration. For this purpose an automatic scale calibration has been included. This appears at the one end of the chart in Figure 8. These steps show the pen deflection when known voltages are applied to the nonlinear system. The conversion from the nonlinear scale to a linear scale in measuring the charts has been found to be a simple process, as the distribution remains the same for many months; in fact, it is possible to measure a peak as soon as the pen has traced over its top without waiting for the rest of the spectrum to be scanned.

In case a peak is too large to be recorded by the system just described, the pen will hit a limit switch at the upper end of the chart, activating a relay whose contacts shunt the input to the recorder system at *B-B′* on Figure 7. Thus, if the input be shunted in this manner by a factor of ten, the range of current that may be recorded accurately will be 200 to 1 instead of the range of 20 to 1 mentioned in the previous paragraph. Of course, it would be possible to have a stepping-type limit switch at the upper end to shunt the input a number of times should an extreme range of ion currents or a need for higher accuracy require more scale expansion. In Figure 8 the mass 28 peak illustrates this shunting system. Although the recorder pen moves downscale very rapidly after hitting the shunting switch, there is a possibility that the top of a peak that will be just off scale on the first range would be missed. To eliminate this possibility the ion voltage is decreased slightly by an amount ΔV so that the peak top will not appear during this discontinuity. As all the peaks appear at a constant accelerating voltage of, for example, 600 volts when the magnetic field is scanning the masses, all the peaks have the same width in voltage. Thus when the voltage change ΔV just mentioned has been adjusted to take care of the range change discontinuity for one mass, there is no further adjustment required as ΔV is the same for all masses. When the pen approaches the region of the speed-up switch after tracing the peak contour at the reduced sensitivity, the shunt is removed, returning the recorder to full sensitivity, and the small additional voltage ΔV is removed from the ion gun. A close inspection of the mass 28 peak in Figure 8 will show the appearance of the peak contour as a result of the processes just described.

Although the method of scanning through the spectrum by varying the magnetic field has the advantages mentioned previously, there remains the difficulty of accurately identifying the masses of the peaks that appear on the chart. A measurement of the current energizing the magnet coils is of little help because of the hysteresis. For this reason a mass marker based on an actual measurement of the field in the gap of the magnet deflecting the ion beam becomes essential. For the mass marker incorporated in the recorder which has just been described, the magnetic field has been measured by spinning a coil in the gap of the magnet by means of a synchronous motor.[7] Leads from this coil are brought to a commutator, and the output from the brushes is carefully filtered. The output from this filter is then directly proportional to the magnetic field and may be used as a basis for a mass-marking circuit. Figure 10 shows the mass-marking generator in position. The principle of the mass-marking circuit is illustrated in Figure 11. The resistors across the contacts of the step relay *C* are so chosen that the voltages from the various taps can be made to correspond to the output voltage from the generator to mark preselected masses. Of course, for a given voltage on the ions a careful adjustment must be made initially with the variable resistance *R*. The operation of the mass-marking circuit is then as follows: as the magnetic field is decreased and approaches the value where, for illustration, mass 15 is focused on the exit slit of the mass spectrometer, the output from the generator *G* becomes equal to the voltage from the step relay *C*. The circuit *A* detects this balance and moves the contact *C* from 15 to the next step, 10, while an auxiliary relay and pen puts a mark on the chart. The voltage from *G* is now greater than that from *C*, but as the magnetic field is further decreased, the generator voltage becomes equal to the voltage from *C* when the magnetic field is the proper value for focusing mass 10; at this instant the circuit *A* again detects the balance, shifting the contact *C* to 5 and again marking the chart. The step relay turns a pointer which indicates the mass corresponding to the last mark on the chart. With some refinements and the use of an add-and-subtract relay, this system has been made active in both directions—that is, with

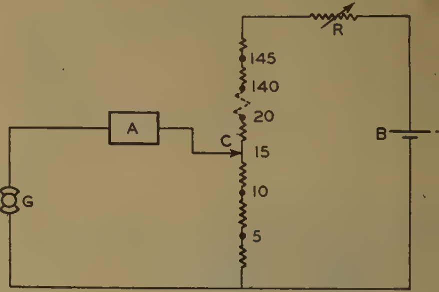


Figure 11. Schematic diagram of the essential features of the mass-marker circuit

either decreasing or increasing magnetic fields. The mass marks are indicated at the bottom of the chart in Figure 8.

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Grounding Principles and Practice

IV—System Grounding

W. R. BULLARD
MEMBER AIEE

Grounding of transmission and distribution systems is considered in this article, the fourth of five based on a series of lectures on the subject which was sponsored by the power and industrial group of the AIEE New York Section during the 1943–44 season. Purposes and methods of grounding at substations, along transmission lines, and in a-c open-wire overhead distribution systems are discussed.

THE SUBJECT of transmission- and distribution-system grounding is divided for convenience into three principal parts, substation grounding, transmission-system grounding, and distribution-system grounding, which will be taken up in that order.

SUBSTATION GROUNDING

The term substation is applied commonly to a great variety of electric stations. Therefore, for a clear understanding of the following it is necessary to keep in mind specifically the types of stations to which this discussion applies. They are: transmission step-up, step-down, and switching stations; distribution substations serving general-purpose primary distribution systems, and industrial substations of large size. Smaller industrial stations have grounding requirements generally similar to those of distribution transformer installations which are treated in the third part of this article. As the discussion proceeds it will be recognized that it is concerned particularly with stations of the outdoor type located in areas where transmission and distribution lines are overhead. However, most of the principles outlined apply equally well to indoor stations and those located in areas where lines are underground. The need for lightning protection in the latter type of station, of course, is generally not present.

Having defined the types of substations under consideration the purposes of grounding may be reviewed briefly as follows:

(*a*). Grounding for lightning and surge protection.

(*b*). System grounding to stabilize circuit potentials with respect to ground and to provide means of circuit relaying to clear ground faults.

(*c*). Grounding of non-current-carrying structures and parts and auxiliary low-voltage circuits, for safety to persons.

Grounding may be employed for one or more of the foregoing purposes in any particular substation. In the early beginnings of grounding practices, the feeling was prevalent that separate grounding facilities should be provided for each purpose. Thus lightning-protective equipment would be connected to one ground or set of grounds, the system ground connection would be made to another set, and so on. This not only resulted in undue expense but also the effectiveness of lightning-protective equipment was unnecessarily poor. Later it became generally recognized that interconnection of all grounds aids in securing maximum effectiveness, the conductivity of each ground supplementing that of the others in the interconnected group. In modern substation grounding practice, therefore, it is common to find either a single all-purpose ground bus, or two or more interconnected busses if the layout is such as to make this arrangement more convenient.

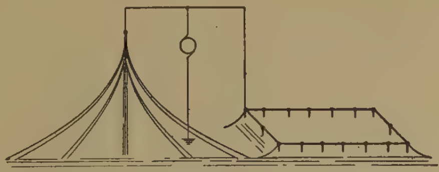

Figure 1. **Point grounding versus distributed grounding**

Grounding is an important feature of substation design and much care in obtaining an effective grounding system can be justified when it is considered that the substation is a place of energy concentration, a switching center upon which continuity of service may be dependent, the location of large and costly electric equipment, and the scene of frequent operating and maintenance work by company employees. If the station is attended, the element of personal safety is of still greater importance.

With the aim of a uniform or near uniform potential of earth surfaces in the area under consideration, well-distributed ground beds consisting of driven rods frequently provide the most efficient use of the money spent for grounding if they can be driven to effective depths without encountering rock or other obstructions. If practicable they should be driven into levels of permanent moisture. Where pile foundations are needed for structural reasons grounds have been made by attaching copper wire in grooves on one side of some of the piles to within two or three feet of the lower ends. These may be used as the sole method of grounding or in combination with other types of electrodes depending upon requirements.

In instances of dry soil or high earth resistivity from other causes, conductivity sometimes is improved by use of salt, char-

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W. R. Bullard is electrical engineer, Ebasco Services, Inc., New York, N. Y.

coal, or other chemicals around the electrodes. In instances of very dry sandy soil or similar conditions of difficult grounding, deep wells have been sunk, with metal casing or immersed plates being used for the ground electrodes. In other instances of extremely difficult grounding directly at the substation site, better facilities have been found relatively near by, such as a stream or other body of water, and use has been made of such facilities by installing the ground bed at the needed distance from the station and extending the ground bus out to the ground bed. Where this is done care must be taken that the ground bed and associated connections do not constitute a high-potential hazard to persons, under fault conditions at the station.

Where ground beds of driven rods are used the most efficient arrangement is with a fair amount of separation between rods. This leads to the common practice of driving a series of rods around the outer perimeter of the station, supplemented by additional rods scattered through the station area at points of connection to lightning protective devices or other important equipment. The conductor interconnecting the rods forms a portion (in some cases the major portion) of the ground bus, and in the case of outdoor stations it may be buried several inches under the surface of the earth.

In thickly populated districts where substantial networks of underground metallic water pipes are available, the inherently low ground resistance of such networks may be made use of by direct connection from the ground bus. However, before using water pipes as the main source of grounding for large substations, conditions should be investigated to make certain that the water pipes have adequate size to carry maximum currents to which they may be subjected, and that the local resistance to ground is adequately low to avoid hazard from high potentials to water consumers in the immediate vicinity and to prevent local high potential gradients at the ground surface in the substation area and vicinity. With respect to the last mentioned consideration, connection to small pipes of high resistance may have the effect of "point" grounding as contrasted with distributed grounding consisting of a number of widely spaced ground electrodes of other types.

Figure 1 represents an attempt to show graphically a comparison of potential gradients at the ground surface for grounding with a single ground rod, and for grounding with a number of rods such as along a rectangular ring ground bus. The distances above ground surface of the various lines represent potentials in the ground at the corresponding points. Note the very steep gradients near the single rod, which might endanger persons or animals standing on the ground. The generator shown, of course, is purely pictorial.

The over-all requirements as to ohms resistance of a substation grounding system naturally depend upon the purposes for which the grounding is used and other re-

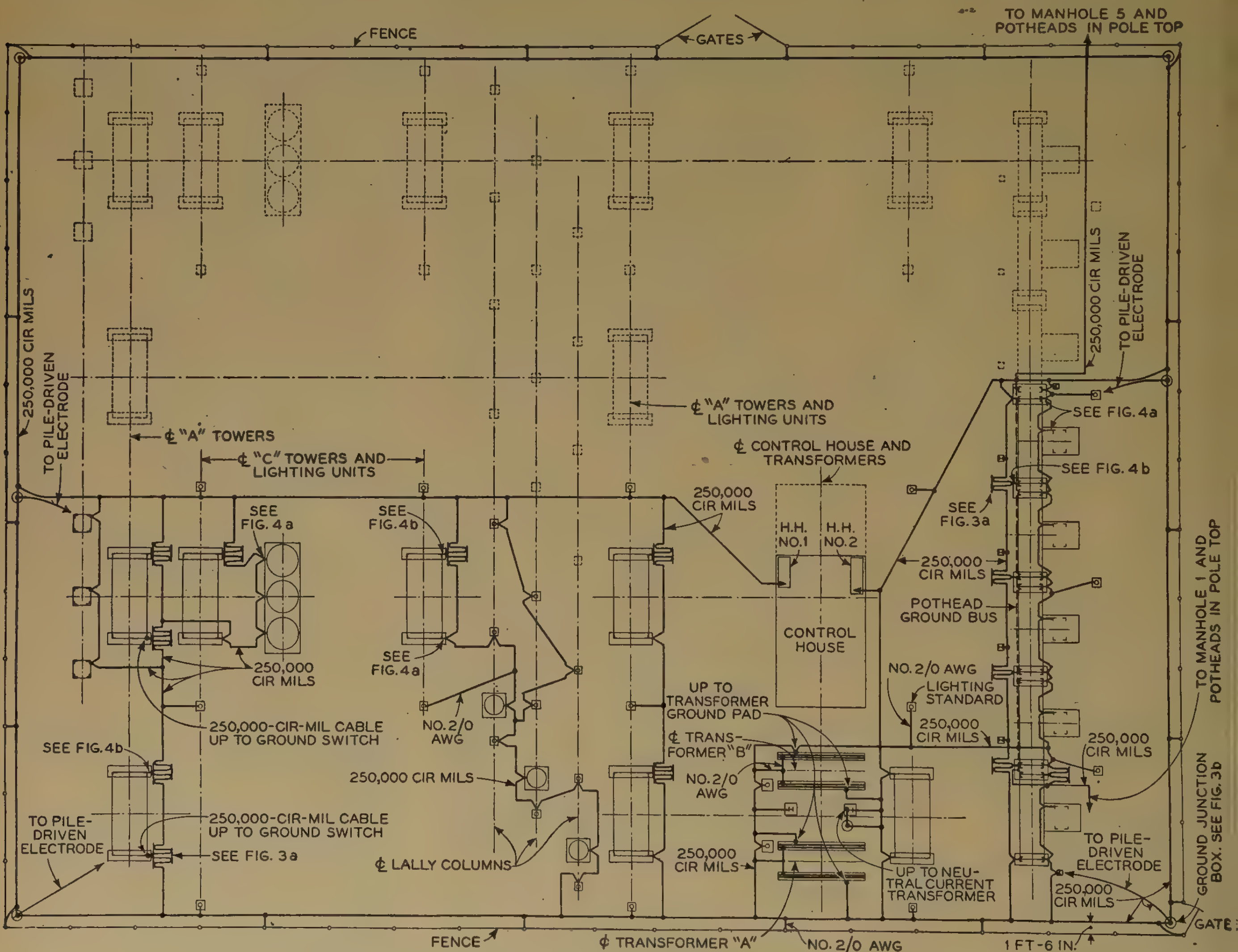


Figure 2. **Plan of typical outdoor-substation ground-bus layout**

Ground cables are buried in the ground at a minimum depth of one foot six inches
All copper cables and bars are tinned at points of connection
All electrical equipment, conduits, cable sheaths, structural steel, and so on, are permanently grounded
Ground resistance, for this installation was specified to be five ohms or less
All power-cable sheaths are bonded to ground cable in all manholes and a potheads

lated factors, such as voltage of station circuits, fault current required for relaying, impedance of circuits and station equipment, and the like. Lightning protection of station equipment by lightning arresters or spill gaps can be made largely independent of ground resistance by interconnection of the ground bus with non-current-carrying parts and circuit neutrals. Therefore, the requirements for conductivity to ground may be determined largely by the needs for system-neutral grounding, including relaying requirements. However, unless the grounding is adequate to avoid potentials on the ground bus, under fault conditions, that would be hazardous to the lives of persons working in and around the station, special precautions must be taken to equalize potentials between exposed structures and objects. This means solidly connecting all such structures (usually including the fence, if of metal) to the ground bus and also providing that any surface on which a person may be standing is substantially at the same potential as surrounding objects. In the case of outdoor stations this sometimes is accomplished by placing steel plates well connected to surrounding structures, switch handles, and the like, for operating personnel to stand upon in locations requiring specific operating duties. In other locations the same purpose of equalizing potentials may be accomplished by the use of buried grids of light conductors a few inches under the ground surface. In extreme cases such a grid may be used over the entire substation area. Also, sometimes it may be desirable to use a ground grid extending outside the fence for a few feet if the fence is of metal, in order to avoid high-potential hazard to persons standing on the ground outside the fence and touching the latter during a fault to ground.

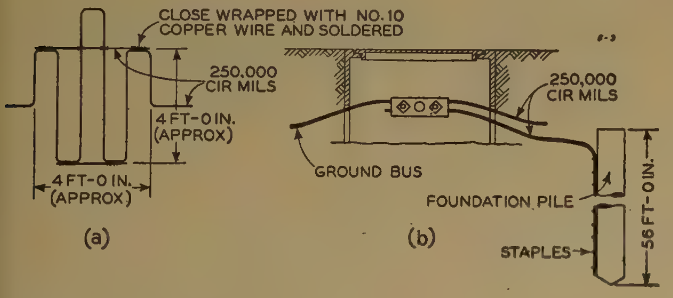


Figure 3. Ground-bus detail

(*a*). *Potential-equalizing grid, buried six inches below grade in front of air-break-switch operating arms*

(*b*). *Bolted connection and pile ground electrode*

Relay circuits, control circuits, and communication and metering circuits commonly associated with substations have low-voltage insulation and ordinarily are connected to the ground bus for removal of static potential, for protection against instrument-transformer failure, and for safety to persons handling or working with the low-voltage equipment. It is essential that large potential differences along the ground bus be avoided to prevent breakdown of the insulation of these circuits from conductor to non-current-carrying parts or from conductors of one type of low-voltage circuit to those of another. This fact and the need for keeping potential differences between any and all exposed parts low for safety to personnel justify a liberal size of ground bus to secure good conductivity, and emphasize the need for well-made grounding and bonding connections throughout.

The ground bus and associated conductors, aside from the question of voltage drop under fault conditions, also must be large enough to insure against burning off or burning open due to fault current. These considerations usually lead to the use of copper for the bus and its associated conductors, and to the use of brazed or clamped connections instead of soldered joints. Special attention should be given to the main loop of the grounding system and to all sections of the bus that may be called upon to handle heavy currents.

It is considered good practice to provide two or more paths to ground for each piece of apparatus that may receive heavy fault currents. The size of each conductor should be ample to carry maximum calculated fault current based upon all equipment in the station being in service and taking into account the number of transformers or other pieces of equipment having their neutrals grounded. When neutrals are grounded through resistors or reactors, consideration should be given to whether these current-limiting devices are provided with by-pass switches.

Liberal size of the grounding bus usually is considered a good investment. The cost is relatively small, and the security afforded is great. The matter of personal safety is of especial importance as there have been a fair number of fatal accidents due to high potential differences between exposed parts during line-to-ground faults.

If the station is outdoor type and the ground bus is buried, the use of copper raises a question as to possible corrosion of the station structure footings because of the electrolytic couple created by the copper and the zinc coating of the structural steel. Because the station footings usually have concrete surrounding the steel the matter may not be of great importance in usual cases.

One influence of modern knowledge and thinking on substation grounding practices that is worthy of special note is that connections from lightning-protective devices to ground bus are now made as short as practicable and such devices are located as near as practicable to one or more of the ground electrodes. In other words, the path to ground for lightning and other surges is made just as short as practicable.

Figure 2 is the general ground-bus layout of a 110/13-kv switching and transformer substation, outdoor type. Note the ring bus and the cross busses of buried copper conductor. Also note the grids at switch operating points for safety of personnel. The substation fence, which is well connected to the bus, is barely visible close to the outer loop.

Figure 3 shows a bolted connection, pile ground, and grid detail of the substation ground system shown in Figure 2.

Figure 4 shows additional detail of the ground bus shown in Figure 2. This shows bolted connections to steel work and a vertical cross section of one of the grids designed to provide safety to personnel when operating switches and the like.

TRANSMISSION-SYSTEM GROUNDING

The grounding of transmission lines will be considered from the standpoint of grounding along the lines, not at the terminals. The latter has to do with substation grounding and has been dealt with in the preceding section. Except for grounding of cable sheaths in connection with underground transmission, or rare cases of multigrounding of neutrals of such few transmission circuits as have neutrals, grounding along transmission lines has to do almost solely with lightning protection. The following discussion therefore will be confined to grounding along overhead lines for purposes of lightning protection.

Throughout this discussion of transmission-system grounding the term ground resistance refers to impulse resistance, which tests have shown to be in general somewhat lower than resistance at power frequency.

As an aid to clarity, it is desirable to review the elementary principles of lightning protection of transmission circuits. The primary purpose of such protection is to improve service continuity by minimizing flashovers and resulting circuit tripouts. The technique of lightning protection has advanced to the point where practically any degree of immunity from service interruption due to lightning can be secured, the limitation being the cost of protection as justified by the benefits gained. Aside from the use of Petersen coils applied at line terminals and therefore making use of substation grounds, there are two principal forms of lightning protection for transmission lines, namely, drainage of surges from the conductors by expulsion gaps, and shielding of conductors by overhead ground wires.

Expulsion gaps may be classed as a special form of valve-type lightning arrester and are connected (with external air gap) so as to bridge the insulation to be protected. They are intended to limit surge potential to values below insulation flashover and at the same time provide a path to ground for the surge current. If the gaps are installed at every structure the latter function is auxiliary to the main function of preventing flashovers and does not require low-resistance ground connections. This freedom from dependence upon ground resistance is an important feature of expulsion gaps and provides for them a particular field of usefulness in situations where grounding conditions are unusually difficult. Thus (except for a special application mentioned further on) where expulsion gaps are used, simple and low-cost types of grounds usually are sufficient, such as the normal footing resistance of steel towers, pole-butt-wrapped grounds, or single driven rods in the case of wooden structures. Expulsion gaps are installed in sets numbering one, two, three, or four units per structure. In the simplest form of connections, one terminal of each gap is connected to the ground lead or to the tower. The other terminal forms one electrode of an air gap to the line conductor. Sets of expulsion gaps may be installed at each line structure, or at every other structure, or at even greater spacings, depending upon the degree of immunity from flashover it is desired to secure. However, as the spacing is increased, ground resistance plays an increasingly important part and expense may be incurred for providing low resistance.

A special type of expulsion-gap application makes use of one of the line conductors as an overhead ground wire in effect and permits the use of only one gap per installation. For this purpose the line conductor so used must be elevated above the other conductors, for example as with triangular spacing. Lightning striking the upper conductor passes through an air gap to the expulsion gap, and thence to the ground lead or tower. In this type of protection the ground resistance is important and is governed by the principles of ground-wire protection which are to be discussed later.

The most generally used form of protection is that of shielding by overhead ground wires. Such ground wires paralleling the line conductors are supported at a higher level than the conductors and spaced from them in such relation that the chances of a stroke of lightning contacting the conductors are minimized, the ground wire or wires taking the stroke instead. Rules for designing geometric configurations of conductors and ground wires to accomplish this purpose have been worked out from experience and laboratory tests. Whether one wire or two is used is a matter of selecting the most efficient design for a given type of line.

The ground wires are connected to earth at intervals along the line, usually at each supporting structure, and the part this grounding plays in the protective scheme is very important. For purposes of explanation a line supported on steel towers and having one ground wire will be assumed, and it is well to remember that this discussion deals with direct lightning strokes since it has been found by field tests over a period of years that practically all flashovers resulting from lightning on 66-kv and higher voltage lines are caused by direct strokes.

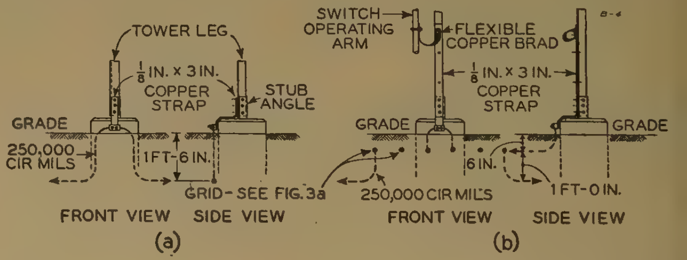
When lightning strikes the ground wire or the tower itself the tower-top potential is raised many thousands or even millions of volts above ground while the line conductors, relatively speaking, stay at practically zero potential. If the ground resistance is high the chances are very great that there will be flashovers from tower to line conductors followed by a flow of power current, and tripping of the line. However, if the tower is well grounded its potential rise will be limited to a value determined by surge current and ground resistance, and if there is proper co-ordination between ground resistance and striking distance across insulators or directly to conductors through the air, line flashover will be prevented.

This is a very simplified explanation of the part that grounding plays. The actual mechanism of development of potential between tower and conductors is complicated by the surge impedances of the ground wire and the tower, by reflections of the surge waves in the tower and along the ground wire to adjacent towers, and by the surge coupling between ground wire and conductors. However, all of this has been worked out to a fair degree and practical formulas developed so that performance can be reasonably well predicted for any given set of conditions. Knowing the frequency of lightning storms in a given area, and having established data giving approximate percentages of number of strokes having various degrees of severity, lines can be designed for any desired limitation on the approximate number of outages per year, the benefits gained being balanced against the cost of the protection. For example, if a line is designed to prevent flashover for all strokes of 80,000 amperes and less, about 95 per cent of strokes will be rendered harmless, the remaining 5 per cent perhaps causing flashover.

Figure 4. Method of grounding tower legs

(*a*). *Towers without switch-operating arms*

(*b*). *Towers with switch-operating arms*



For a given protective level, and a given number and position of ground wires, protective design becomes a matter of coordinating ground resistance with line insulation, the latter being represented by the porcelain insulators in the case of a steel-tower line. Span length also is an important factor, but in general for a given span length the insulation must be proportional to the ground resistance at individual towers or vice versa. However, insulation is relatively costly, particularly since the dimensions and consequent cost of the towers themselves is influenced by the amount of porcelain insulation provided. Therefore, it usually is found less costly to decrease ground resistance than to increase line insulation for purposes of lightning protection, the insulation level then being determined by the normal line switching surges, and ground resistance being determined by the desired level of lightning protection.

The footings of steel transmission towers are in contact with soil and provide a certain amount of grounding. But on the foregoing basis of design the ground resistance of tower footings seldom is sufficiently low to provide substantial immunity from line flashover as a result of lightning. Therefore, supplementary means of grounding usually must be used. This may take the form of driven rods in locations where permanent moisture can be reached by the rods. The rods may be from 10 to 50 feet long and are driven around the base of the tower. In accordance with the principle that good separation must be maintained between electrodes to obtain conductivity the rods should be kept well away from the underground sections of the tower legs.

In situations involving dry soil, rock near the surface, or other factors preventing efficient use of driven rods, the counterpoise may be used instead. The counterpoise consists of one or more bare conductors buried a short distance beneath the surface of the ground and extending for some distance away from the tower in two or more directions.

The protective effect of the counterpoise is more than that of the conductivity to ground which it affords. Initially, when the surge reaches it, each wire behaves like a surge impedance of 150 to 200 ohms. Following the initial instant this impedance rapidly decreases, until it reaches the actual ohmic resistance to ground, the time taken for it to reach this resistance being related to the length of the counterpoise. In the flashover characteristics of insulators, time is an element, as well as magnitude of surge potential. The quicker the potential is limited or reduced, the more effective will be the measures taken to prevent flashover. Thus for a given total length of counterpoise conductor, the protection afforded will be somewhat more effective if the length is expended in several wires radiating from the tower than if installed as a single stretch of wire. The more widely separated the wires are the more effective they will be as independent elements of the counterpoise system, and since it is found that the gain to be realized from more than four wires is not great, it might be concluded on first thought that an ideal arrangement would be four radial wires equally spaced from each other. However, there are factors other than the geometry and electrical efficiency to be considered. Questions of right-of-way frequently make impracticable the use of counterpoise wires at right angles to the line. Discontinuities, that is "loose ends" of the counterpoise wires, offer possibilities of high potential gradients along the ground surface under surge or fault conditions. These and other considerations make popular the use of continuous counterpoise wires parallel to the line, sometimes a single wire in the center of the right-of-way, sometimes two, one at each side of the right-of-way, depending upon the degree of protection required.

The effectiveness of counterpoises is found to be generally independent of the conductor diameter and of whether the wires are of copper or of steel. Therefore, the selection of the size of wire may be governed largely by mechanical considerations, and selection of the type of wire may be governed largely by questions of durability. Copper wire buried in the ground naturally may be considered more resistant to corrosion than galvanized steel, however, the latter possesses the advantage of avoiding an electrolytic couple that might tend to shorten the life of the tower footings. Such a couple can be avoided even with copper wires by the introduction of a short air gap instead of direct connection to the tower.

The foregoing discussion of ground wires and related grounding has been limited to steel-tower lines. Overhead ground wires may be used on wooden-structure lines, and the same principles of grounding apply except that the insulation can be greatly augmented by the surge insulation value of the wood structure. For example, one foot of wood is considered roughly equivalent to one suspension-insulator unit. Butt-wrapped grounds on wood poles are generally equivalent to one ground rod driven to the same depth.

Figure 5 shows a wood H-frame structure supporting a 154-kv line, with two overhead ground wires suspended at the ends of a steel crossarm at the pole tops. Height of the ground wires above and their offset from conductors insure that practically all lightning strokes will contact the ground wires and not the conductors. Ground leads down each pole connect to two butt-wrapped grounds tied together by an underground connection. The impulse insulation of the insulators plus wood crossarms is slightly greater than the flashover value through air between conductor and ground wire. With ground resistance at the base of each structure amounting to 20 ohms or less, and based on commonly accepted data and lightning-propagation theory, only about three or four per cent of all strokes making contact with the ground wires result in voltage at the tower top sufficient to cause flashover between ground wire and conductor.

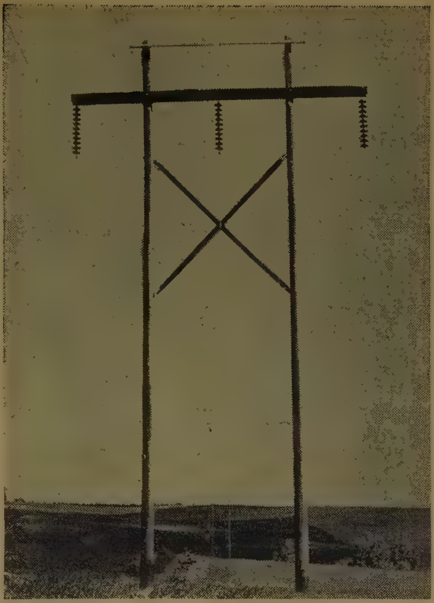


Figure 5. **Wood H-frame structure supporting a 154-kv line, with two overhead ground wires suspended at the ends of a steel crossarm at the pole tops**

DISTRIBUTION-SYSTEM GROUNDING

The following discussion will be confined to a-c systems since they constitute the great bulk of distribution systems. It also will be limited principally to open-wire overhead systems, although many of the statements will be recognized as equally applicable to underground distribution.

The purposes of grounding in a-c distribution systems are in essence similar to those of grounding in substations which were listed in the first part of this article. However, in distribution systems, the matter of safety to persons looms large as a governing factor since it is through these systems that electric service is brought into the premises of the ultimate users. Grounding is an important factor in providing safety to the public in its use of the service —safety from overpotentials and safety by virtue of a stabilized relation of service potentials to ground. Safety to private and public property from fires of electrical origin also is dependent to some extent on the grounding of low-voltage distribution circuits. Grounding of fixtures, exposed non-current-carrying parts of wiring systems, and certain types of utilization equipment in consumers premises is a related aspect of safety to the public.

Grounding of distribution primary circuits has two principal purposes, stabilizing circuit potentials with respect to ground to avoid overstressing insulation, and providing a path for ground faults to aid in the operation of overcurrent devices and secure prompt disconnection under fault conditions. This latter function plays an important part in providing safety to the public because, in such instances as crosses between primary and secondary circuits and breakdown of insulation in transformers, the more rapidly the primary circuit is disconnected the less opportunity there is for the development of hazards to life and property.

Lightning protection in distribution systems differs appreciably from that of transmission lines as described in the preceding section. Distribution-system insulation levels are inherently low and it is not economically practicable to build up an effective system of shielding from direct lightning strokes such as described in the discussion of overhead ground wires for transmission lines. A certain amount of line tripouts from lightning, including direct strokes and other surges of relatively high magnitude, are accepted as a matter of course and service reliability is secured through the use of automatic-reclosing circuit breakers, duplication of circuits in some cases, and other measures that minimize the effects of circuit tripouts, rather than prevent them. Direct lightning protection in overhead distribution systems is largely limited to prevention of insulation failure in transformers and other equipment where repair or replacement is costly and time consuming. The forms of protection most commonly used are valve-type arresters, expulsion gaps, and open-spill gaps.

As in substation practice, early distribution-system grounding practice commonly provided separate grounding facilities for each grounding function. But the modern trend has been strongly toward pooling all grounding facilities and making use of their combined effectiveness for all purposes. Generally speaking not only does such practice aid in securing low ground resistance thereby making best use of money and effort spent in grounding, but also interconnection of various grounded circuits and objects tends to equalize potentials between them under fault or other abnormal conditions, thereby improving safety.

Multigrounding of secondary-circuit neutrals became common early in the development of grounded a-c distribution systems. Individual grounds at transformers, and at services, interconnected through the circuit neutral, and sometimes supplemented by grounds at other locations, constitute the essence of multigrounded secondary neutrals. The effectiveness of the grounding is greatly increased by connecting the neutral conductors to form a network where configuration of the system is such that this can be done readily.

Multigrounding of primary neutrals developed more slowly but came into common use with the development of 2,400–4,160-volt four-wire grounded-neutral systems. Soon thereafter as a logical step, in line with the modern trend toward pooling of grounding facilities, the multigrounded common primary and secondary neutral came into use. In addition to aiding grounding efficiency, it has the advantage of requiring only one neutral wire instead of two, not only saving expense and material but also aiding in relieving conductor congestion.

In overhead practice the common neutral usually is located at the same general level on the pole as the secondary conductors and may be completely uninsulated, that is, clamped directly to the pole, or may be supported on light insulators.

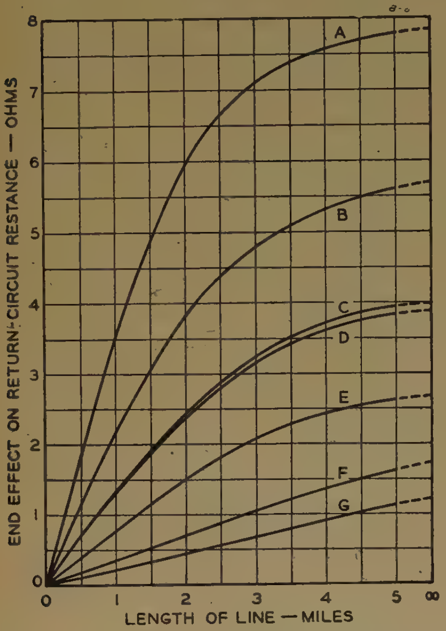


Figure 6. End effect on return-circuit resistance of multigrounded neutrals for the condition where average resistance of individual grounds divided by number of grounds per mile equals 20

A—Number 8 solid
B—Number 6 solid
C—Number 4 stranded
D—Number 4 solid
E—Number 2 stranded
F—Number 2/0 stranded
G—Number 4/0 stranded
All conductors copper; sizes in American Wire Gauge

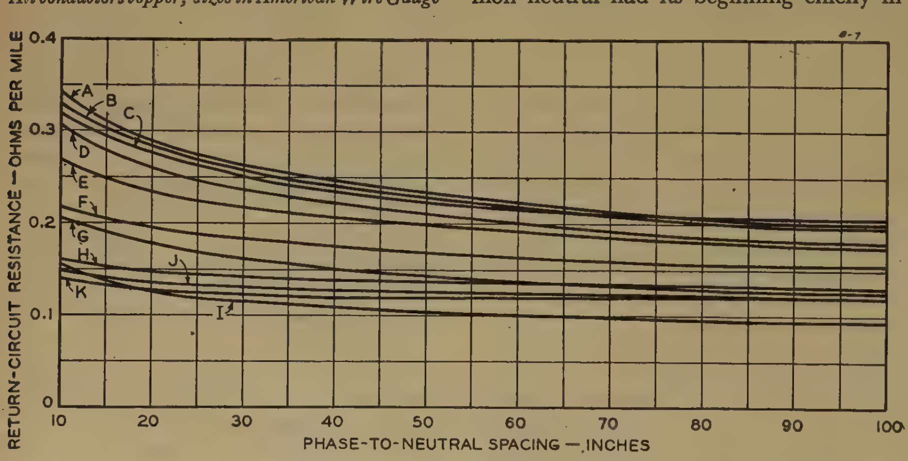


Figure 7. Return-circuit resistance per mile of multigrounded neutrals for zero-resistance grounds

A—Number 4 stranded copper
B—Number 4 solid copper
C—Number 6 solid copper
D—Number 2 stranded copper
E—Number 8 solid copper
F—Number 10 solid copper
G—Number 2/0 stranded copper
H—Number 4 solid steel
I—Number 4/0 stranded copper
J—Number 6 solid steel
K—Number 8 solid steel
Copper-wire sizes in American Wire Gauge; steel-wire sizes in Birmingham Wire Gauge

As load densities have increased in modern times and distribution distances have been increased by the expansion of rural electrification, need has been found for higher distribution primary voltages, and overhead primary systems operating at 11 and 13 kv have come into being. These usually are four-wire grounded-neutral systems or single-phase branches of such systems, and the common primary and secondary multigrounded neutral idea has been applied to them with the same benefits that accrue in the case of the lower voltages. While there are examples of extensive systems of this higher-voltage type in urban areas, most extensive use has been made of them in rural areas. Here the final branches serving individual farm customers may be single-phase lines consisting of one insulated and one multigrounded conductor, secondary mains usually being absent, and customers being served through individual transformers.

Whereas in urban areas multigrounded neutral networks may be continuous over the majority of the territory served and may involve hundreds of thousands or even millions of individual grounds, in rural areas connection in networks is not often practicable and grounds are spaced more widely. Also, water pipes used as grounding means, so effective in urban areas, generally are lacking in rural areas. Secondary mains frequently are not present, customers being served through individual transformers. In rural areas, therefore, all available means of making the grounding system really effective are needed. Use of the multigrounded common neutral had its beginning chiefly in urban areas, and the practice of tying in secondary grounds to the primary neutral in rural areas was approached with some hesitation, there being a feeling that this close association of primary and secondary circuits should not be practiced in any except those situations which provided conditions of very low ground resistance. It was realized, however, that accidental crosses between primary and secondary conductors, occasional breakdown between primary and secondary windings of transformers, flashovers of transformer bushings, and the like could not be prevented, and that the more effective the grounding system, the greater the safety under such occurrences. Therefore, the common-neutral idea was applied in rural areas, cautiously at first but more confidently as experience with its use was gained, until now the practice is widespread and commonplace. Where secondary mains are not present the term "common neutral" means that the grounded secondary neutrals of transformers are connected to the multigrounded primary neutral.

The full extent of the effectiveness of multigrounding of neutral conductors is not appreciated by many engineers. Studies have shown in some situations that even though pole-butt grounds may have considerably higher resistance than rods driven to a greater depth, the same amount of money spent for pole-butt grounds instead of for driven grounds may give lower over-all ground resistance for a multigrounded neutral. A larger number of butt grounds must be used but the cost per ground is considerably less. By "pole-butt ground" is meant a spiral of wire around the butt with perhaps a pancake at the bottom. Scrap wire can be used for this purpose, but, of course, such grounds must be installed at the time the poles are set. The foregoing statement should not be taken to indicate a general recommendation for pole-butt grounds, since there may be conditions of very dry soil down to depths well below the ground surface, for which they would not be effective.

Multigrounding is also effective in reducing the impedance of the neutral conductor and improving voltage regulation in a circuit in which the neutral carries some current. Consider a neutral conductor of an overhead open-wire circuit, grounded at numerous equally spaced points along its length, each ground having the same resistance. Neutral current from the source end of the circuit will flow only in the neutral conductor until the first ground is reached, where a part of it will escape to the ground. At the next ground more will escape, and so on until, if the line is long enough, a stable division between neutral-conductor current and ground current will be reached, determined largely by electromagnetic effects. At the load end the process is repeated in reverse order. At each end of the line a plot of current in the neutral conductor versus distance along the circuit takes the form of a hyperbola. The total effective neutral impedance is made up of two end effects which are dependent upon this hyperbolic decay of current in the neutral, and of another component that is uniform from point to point along the line and corresponds to the division of current where it becomes stabilized at some distance from the ends.

The following comparison illustrates the effectiveness of multigrounding in reducing impedance. The figures are for a three-phase four-wire line five miles long with number 6 American Wire Gauge hard-drawn copper conductors for the phase wires carrying a single-phase load of ten amperes line to neutral.

Neutral Conductor	Voltage Drop in Per Cent of Sending End (7,200 Volts)
Number 6 American Wire Gauge copper ungrounded	3.63
Number 6 Birmingham Wire Gauge steel multigrounded	2.61
Number 6 American Wire Gauge copper multigrounded	2.29

Figure 6 shows end effect on return-circuit resistance of multigrounded neutrals for grounding conditions such that the ohms per ground divided by number of grounds per mile equals 20. The curves represent that portion of return-circuit resistance caused by the varying amounts of current in the neutral conductor and in the ground at various points near the end of a uniformily grounded neutral. The value at the flat portion of the curve represents rather closely the resistance to ground that would be measured at one end of a very long neutral. For such a long neutral the total return-circuit resistance is obtained by taking two of these maximum values, one for each end, adding them together, and adding to this sum the value from Figure 7, corresponding to the same size of conductor, after having multiplied this latter value by the length of circuit in miles.

Figure 7 shows return-circuit resistance of multigrounded neutrals for zero-resistance grounds. This is the unit resistance per mile corresponding to current conditions in the middle portions of long multigrounded neutrals. Combined with the end effects shown in Figure 6 it can be used to determine the over-all resistance of the return circuit consisting of neutral conductor and earth in parallel.

Connection of effectively grounded guys to the multigrounded neutral constitutes extension of the principle of multigrounding, and results in reducing ground impedance of both the neutral and the guy. Therefore, this practice is often used instead of inserting insulators in the guys, under conditions where National Electrical Code requirements permit.

As stated previously, direct protection from lightning in overhead distribution systems is largely limited to prevention of insulation failure in transformers and other equipment where repair or replacement is costly and time consuming. The distribution transformer, of course, is the piece of equipment most frequently involved. Here again by pooling ground facilities greatest effectiveness is secured. During a period of a number of years of extensive field observation it was shown that if the ground lead of a lightning-protective device protecting the primary side of a transformer be connected to the secondary neutral (or better still to a common primary and secondary neutral) the quality of the protection provided is greatly increased. This, of course, is because the protective device then bridges directly the main portion of the insulation to be protected. But in addition grounding is improved by the addition of the lightning-arrester ground to the common grounding facilities. It is small wonder then that this interconnection has become a common feature of modern practice. There are several varieties of actual ground connections, some of them involving the use of spill gaps in the ground leads in lieu of direct connection. The most effective form of connection purely from the standpoint of lightning protection is one in which primary and secondary neutral, lightning-protective device, and transformer tank all are connected together and to ground. However, in some situations where it is desired to use the insulating value of the wood pole as a measure of safety to workmen, it is preferred not to ground the tank directly. In such cases a gap may be used between the tank and the ground connection. In other cases, as for instance, where primary and secondary neutrals are not made common, gaps may be inserted between the lightning protective device and either or both of the two neutrals. These various arrangements are shown diagrammatically in Figure 8.

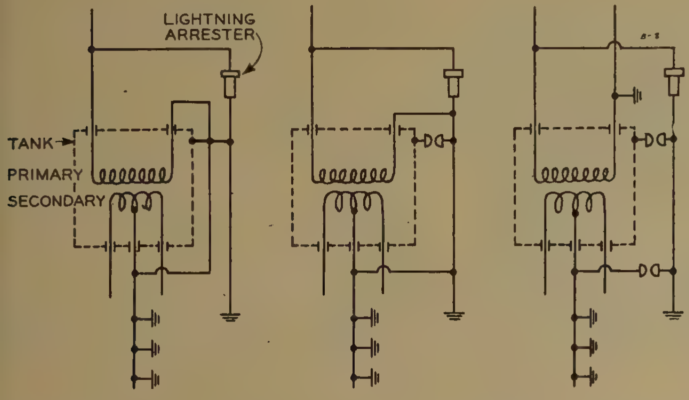


Figure 8. Lightning - protection connections for distribution transformers

It will be gathered from the foregoing that in distribution systems grounds are to be found at transformers and other equipment, serving purposes of circuit neutral grounding, and lightning protection; also as pole-butt grounds on poles other than those that carry transformers and the like. In addition there are neutral grounds at services. Ground electrodes may be of various kinds, direct connected to continuous underground water-piping systems being preferred, driven grounds and pole-butt grounds probably being next in order of extent of use. Generally speaking, by employing the best available means conveniently at hand for making individual grounds, and by making best use of the principle of pooling ground facilities, adequate safety is provided. The chief aims usually kept in view are:

1. Low over-all ground resistance to:

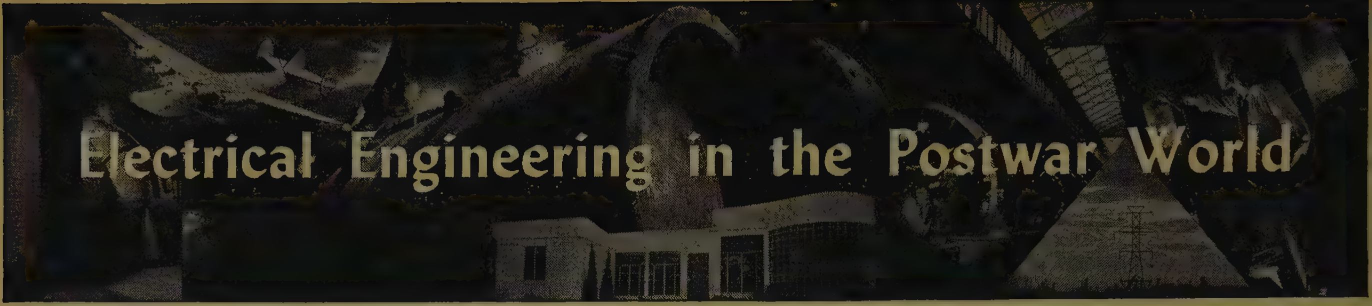
(*a*). Avoid excessive overpotentials in case of faults between primary and secondary circuits. Maximum potentials can be calculated from available maximum fault currents to ground and over-all ground resistance.

(*b*). Provide for positive operation of overcurrent devices in case of faults to ground. Under many conditions this may be more important than (*a*).

2. Avoidance of large potential differences between adjacent objects or circuits at locations where persons may be exposed to them. Frequently this condition can be met best by interconnection of the objects or grounded conductors involved.

3. Provision of conductors adequate to carry all ground currents likely to be involved, without burning open, and without excessive heating in locations where fires might result.

In consumers' premises, grounding of exposed metallic parts of wiring systems and of some types of utilization equipment is practiced for safety. The National Electrical Code deals in detail with such grounding. Important as it is as a safety measure, grounding is not always the only effective method of providing personal safety. Insulation is an alternative and in some cases may be preferable. For example, one of the most common causes of injury to persons from electric shock is the handling of portable trouble lamps or hand lamps under conditions where good contact is made with grounded surfaces by other parts of the body. If the lamp has a metallic shell poorly insulated from the current-carrying parts the results sometimes are fatal. Grounding of the lamp-socket shell may not be fully effective as a remedy since it is difficult to insure the effectiveness of such grounding where it has to be supplied through a flexible cord that may be subjected to much abuse. A simple and quite effective measure is the use of an insulating covering for the shell, or a shell of insulating material. This is only one example. There are others, and, in providing for safety, grounding should not always be considered to be a complete and absolutely indispensable measure.



Electrical Engineering in the Postwar World

XII—Developments in Radio and Television

W. R. G. BAKER
MEMBER AIEE

If electronic progress follows the pattern set after World War I, the next decade will see the expansion of techniques nurtured by military need: frequency modulation, television, facsimile, and radar. Economic considerations, however, probably will set the rate and limit of their expansion.

THE PRESENT SYSTEM of sound broadcasting is the result of certain tools and techniques, the development of which was accelerated greatly by the communication demands of World War I. As a result of this scientific development, after the few years required for the reduction of these military tools and techniques to commercial practice, there began the commercialization of sound broadcasting based on amplitude modulation.

In surveying the history of the technical development of sound broadcasting, it is to be noted that there was continuous stimulation from technical advances up to the early 1930's. Also it must be noted that these improvements were, to a large extent, the result of the extension and refinement of the original tools and techniques. During the past few years, in fact up to a time just prior to World War II, the technical advances in sound broadcasting were of secondary importance. It appears as though the momentum gained through the original technical advances had been dissipated by the late 1930's.

In considering the expected developments in radio and television during the approaching postwar period, perhaps we should examine first the technical advances which have taken place during World War II. We may find that history repeats itself and that we have available new tools and techniques which will determine the probable trend in the growth of the new and the extension and expansion of the existing mass-entertainment businesses.

Considering only such technical facts as may be discussed and recognizing that there exists a mass of technical information which has not been released to the public, we can perceive certain important trends.

The factors to be noted are as follows:

1. Prior to World War II the utilization of the frequency spectrum for commercial radio and mass-entertainment purposes was for technical reasons restricted to frequencies under 100 megacycles. As a result of the technical advances fostered by World War II, certain services now employ frequencies as high as 1,000 megacycles, and some work has been done at 3,000 megacycles. This means that the utilization of the common denominator of all radio and television services, that is, the frequency spectrum, has been opened up by a ratio of 30 to 1.

2. We know that World War I produced sound broadcasting and greatly extended radiotelegraphy through electronic means, that is, by the electron tube. World War II has resulted in the development of a new system for the transfer of intelligence also based on electronics, namely, radar. Although practically all technical information pertaining to radar is still restricted for reasons of security, it is no secret that the tools and techniques evolved for its wartime utilization will have a direct effect on the mass-entertainment services during the postwar period.

3. Tools and techniques have been developed, which when converted to commercial practice will permit the utilization of the frequency spectrum up to perhaps 3,000 megacycles. How long it will take to reduce these tools and techniques to commercial practice is a very uncertain factor. However, it is apparent that the utilization of frequencies under 500 megacycles will be accomplished much more quickly than in the higher range, for example, between 2,000 and 3,000 megacycles.

4. An important factor, and one which perhaps is not appreciated fully, is that during the war thousands of young men have received a fairly good technical training in electronics. It is probable that the rapid commercial development of television would be retarded, if these trained men were not available for the engineering, marketing, and production of television equipment.

5. Before the war a number of components of major importance in television were not in mass production, therefore costs were high. War production has required mass production of many of these components which may result in appreciably lower costs during the postwar period. Probably one of the outstanding items in this category is the cathode-ray tube. In its case, standardization and mechanization of manufacturing processes should be reflected in important reductions in cost.

6. There is another factor which, though not strictly a technical one, does have a bearing on the postwar course of radio and television. This factor is obsolescence; not so much obsolescence of the sound-broadcasting transmitter equipment, although even here new methods have resulted in the more efficient generation of high-frequency power, but, particularly, obsolescence of the broadcast receiving sets in the homes of consumers.

The growth of amplitude-modulation sound broadcasting in the United States up to World War II is indicated by the fact that there are in operation about 900 broadcast transmitters, four nation-wide networks, and approximately 38 regional networks and group-operated stations. These transmitters serve perhaps 60,000,000 broadcast receivers.

It is obvious that during World War II obsolescence, particularly as applied to broadcast receivers, is working in favor of acceptance of receivers incorporating new technical features when production can be resumed. Any changes or additions, especially when they affect the entire system of broadcasting, should be accepted more readily, because, for a period of years, no new receivers have been built. Such being the case, the latest advances can be applied to a large portion of the new receiver production and a load for new types of transmitters can be built up rapidly.

While there are a great number of developments which will affect the electronics industry during the postwar period, the mass-entertainment section of the

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W. R. G. Baker is a vice-president of the General Electric Company, Bridgeport, Conn., and chairman of the Radio Technical Planning Board.

industry will be by far the most important from the viewpoints of creating jobs and total dollar volume. The truth of this is evidenced by the fact that just prior to the present war sound broadcasting in all of its phases represented an annual volume of over $1,000,000,000.

Keeping in mind the six points previously listed, we shall consider the postwar developments in sound broadcasting and television.

Frequency modulation is a new system of sound broadcasting. Its present position in the frequency spectrum is from 42 to 50 megacycles. It is quite probable that after the war the upper frequency limit may be raised.

Frequency modulation is practically free from static and, in addition, suppresses other interfering noises. With amplitude-modulation broadcasting, the desired signal must be about 100 times as strong as the interference, if clear reception is to be obtained. With frequency modulation, the desired signal need be but twice as strong as the unwanted signal. In other words, for good clear reception at a given location, a standard broadcasting signal must be at least 50 times as strong as the frequency-modulation signal.

In terms of power, this means that it takes some 2,000 times as much power at a standard broadcasting station to deliver clear reception at a given receiver as it would for a frequency-modulation station operating on the same frequency at the same place.

Standard radiobroadcasting is more powerful at night than in the daytime. This fact results in interference at the perimeter areas of standard stations operating on the same frequency—particularly at night. With frequency-modulation broadcasting, on the other hand, operating on high-frequency channels, the radio waves travel outward in all directions to a distance two or three times the line of sight, perhaps as far as 100 miles under some conditions, and have about the same coverage areas day and night.

Suppose, for example, there are two 250-watt stations: one a standard broadcasting station operating on the 1,400-kilocycle channel, and the other a frequency-modulation station. At 250-watts power, the standard broadcasting station's daylight range might conceivably be 13 miles. At night, however, it would be found that its range would be perhaps five miles. This represents the distance from the station in which a practically interference-free signal can be obtained in a receiver. The frequency-modulation transmitter, on the other hand, would provide about a 20-mile day-and-night interference-free signal coverage.

With amplitude modulation if a radio receiver is tuned to a nearby standard broadcasting station, and the receiving antenna picks up even the faintest signals from a distant station operating on the same frequency, there will be a steady interfering note accompanying the wanted reception. If the strength of signals from the unwanted station is even $^1/_{100}$ the strength of the wanted signals, there will be interference. Thus, an amplitude-modulated transmitter 1,000 miles away may interfere with reception from a wanted station. The need for spacing amplitude-modulation stations on the same frequency so far apart is the major limiting factor in the total number that can be operated in this country.

Frequency-modulation stations do not set up such interference. Unwanted frequency-modulation signals must be at least one half the strength of the desired signal before interference results. Because such a high ratio of interfering power is required to disturb reception, frequency-modulation stations can be spaced geographically so that each frequency-modulation channel available can be used by a number of stations.

Frequency modulation is practically free from static and other interfering noises. It suppresses the annoying interference from distant stations. It provides a uniformly high standard service both night and day. These are all important factors from the viewpoint of community service. But, in addition, the frequency-modulation system of broadcasting provides for the transmission of the range of audible frequencies up to 15,000 cycles as compared with the 5,000-cycle range of our present amplitude-modulation system.

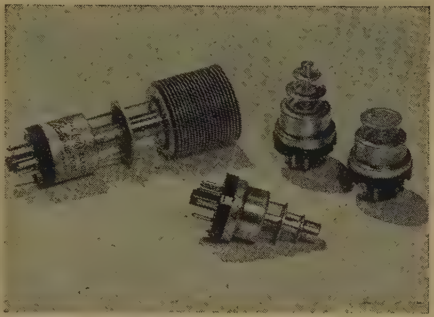


Figure 1. Four models of the General Electric "lighthouse" tube which is expected to play an important part in the postwar development of television, radio relaying, and other ultrahigh-frequency services

At the start of the war there were 43 commercial frequency-modulation stations and six experimental stations. Also, there were perhaps 500,000 frequency-modulation receivers. There are now 210 applications for frequency-modulation broadcast transmitters in the hands of the Federal Communications Commission. As a matter of general interest and as an augury of the future, it may be mentioned that there are also on file 77 applications for amplitude-modulated broadcast stations and 59 television stations.

It is expected that ultimately there will be well over 1,000 frequency-modulation transmitters in the United States. They not only will serve metropolitan and urban areas but also make possible new and additional service to small communities, which now have inadequate service or none at all. There are 606 cities in the United States, aside from the 96 metropolitan centers, having populations in excess of 10,000 and 579 of them do not have broadcasting stations. Although 331 are contiguous to the metropolitan centers, from which they obtain various degrees of programming service, many of them would benefit by the erection of local stations.

More than 15,000 cities or towns having populations of less than 10,000 are without local broadcasting facilities, and many of them undoubtedly would derive substantial benefit from the operation of local low-powered frequency-modulation stations. They would improve, and add significantly to, the ever-increasing service which standard broadcast stations have rendered to such areas.

The influence of low-power stations in the outlying and smaller communities is important. Such local broadcasting stations are destined to become an essential part of the American broadcasting system. They may be expected to have an important influence on business, social, religious

Figure 2. Exterior of the General Electric television and frequency-modulation transmitter station in the Helderberg Mountains near Schenectady and Albany, N. Y.

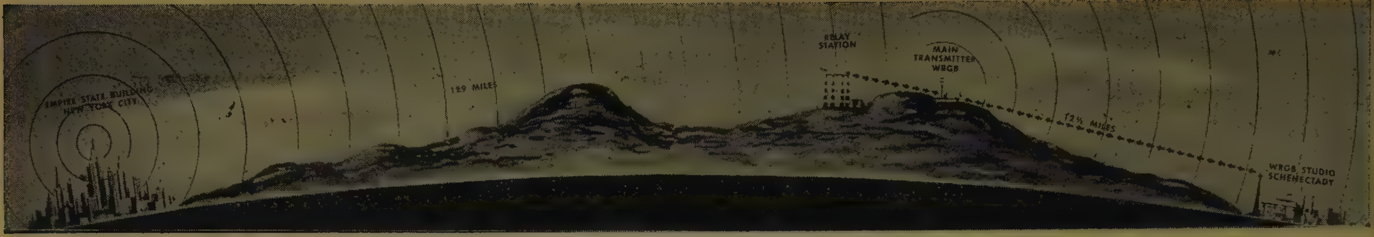


Figure 3. How television programs are relayed from New York to Schenectady for rebroadcast from station WRGB

educational, political, and agricultural activities. They will create new interest in local, social, and political matters, they will afford local entertainment talent an opportunity to develop, and they will broaden generally the outlook of people in smaller communities.

Frequency modulation also will permit expansion of the noncommercial broadcast services, which today are offered by approximately 40 stations. These stations are supported by universities, agricultural colleges, polytechnical schools, vocational institutions, Bible institutions, and churches. Part of the frequency-modulation radio spectrum (presently between 42 and 43 megacycles) has been set aside by the Federal Communications Commission for these noncommercial educational broadcasting services.

It can be seen readily, therefore, that many people who have wished to operate standard broadcasting stations and who were prevented in the past by the lack of space in the frequency spectrum will be in a position to obtain the necessary licenses. This fact is of importance to the listening public, to the radio manufacturing industry, and to broadcasters.

As the size of the national frequency-modulation audience increases, there should be sufficient frequency-modulation stations across the country to permit the organization of new national networks comprised of frequency-modulation stations. For all practical purposes, frequency modulation, with its present allocation in the radio spectrum, will provide as many broadcasting frequencies as there will be broadcasters to use them. However, the number of stations doubtlessly will be limited by economic considerations.

Probably the ultimate in mass-entertainment service is television. Perhaps for that reason, it is, at the moment, by far the most complex both technically and economically. As a sign of its technical complexity, it should be noted that the channel width for a 525-line television picture is six megacycles, as compared with a ten-kilocycle channel for amplitude-modulated sound broadcasting and 200 kilocycles for a frequency-modulated sound channel. In this six-megacycle channel must be placed the video signals plus the associated synchronizing impulses, together with the frequency-modulated sound signals.

Television is particularly complex in being one of the so-called lock-and-key services. The transmitter and receiver must be designed so that any receiver may receive the programs of any transmitter; for example, the synthesis of the picture which takes place on the face of the picture tube in a television receiver must be in synchronism with the analysis of the original scene as viewed by the camera tube in the television studio.

As the result of the work of the National Television Systems Committee, there was submitted to the Federal Communications Commission on March 20, 1941, a group of standards recommended by the radio industry. On July 1, 1941, the Federal Communications Commission approved these standards substantially as submitted and followed with the licensing of commercial television transmitters. However, before any great progress had been made, all work was discontinued because of the war.

At present nine television transmitters are operating in the United States. The number of television receivers in the hands of the public is approximately 10,000. The television industry is confronted with a number of problems, both technical and economic.

There is the question of whether or not a 525-line picture provides sufficient detail to hold the interest of the public. If greater detail be necessary, then the channel width must be increased, which in turn involves the use of the higher-frequency portions of the spectrum, perhaps about 400 megacycles.

The widening of this channel to provide for a picture of increased resolution suggests that the channel width should be further increased to perhaps 15 to 20 megacycles to permit color television.

Then there is the problem of interconnecting or chaining television transmitters. Certainly, if television is to become a national service, television transmitters must be connected for network operation.

Two lines of attack on this problem are evident, namely, radio relays and the use of coaxial cable. It is too early to deduce the probable solution, although there is a real possibility that both relays and cables may be utilized.

There is the further problem of the program material and how the cost of programs will be recovered. Naturally, all program-originating sources, such as the legitimate theater, the motion-picture industry, and the like are vitally interested and concerned with a service which may become a serious competitor. Whether television will become an ally or a competitor to such forms of entertainment remains to be seen.

From the experience with sound broadcasting, one might predict that the program cost will be recovered through advertising. While this is certainly a reasonable prediction, it is again perhaps too early to say that this will be the only source of revenue.

Television in the home is but one possible application. There are, in addition, such applications as the theater, display purposes in department stores, and industrial purposes. While some work has been done in these fields in both the United States and England, such applications have not proved their worth either technically or economically.

There is no doubt but that the technical advances due to the war will accrue to the advantage of television, although some time will be required to adapt these new tools and techniques to commercial application. In certain instances, such as the cathode-ray tube (picture tube), the benefits of better manufacturing processes will be available almost immediately.

Since the frequencies employed in both frequency modulation and television permit what is essentially line-of-sight propagation, a considerable number of transmitters will be required to provide a complete national coverage. Also, since for the same coverage the first cost of television transmitting equipment is, at the moment, appreciably greater than for sound broadcasting, it may be expected that the initial expansion will take place in the large urban centers. The fact that large urban centers are generally a good source of program material is also an important factor. Certainly, television will come after the war. We must, however, not expect it to blossom on nation-wide scale at once. A large investment must be made in television transmitters and in a system of connecting transmitters for network televising.

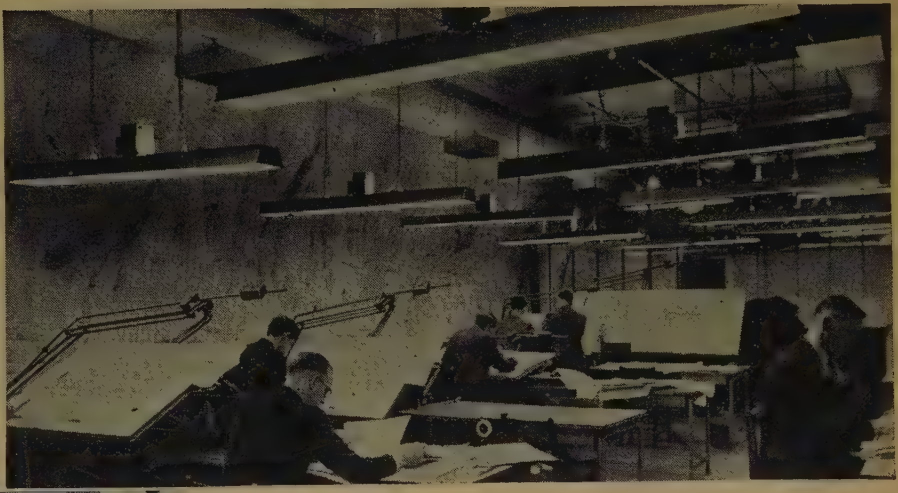
There is a third service, radio facsimile, which eventually may find application in the field of mass entertainment. Prewar attempts to commercialize this service for home use were not very successful.

During the war the applications of facsimile have been extended with a corresponding improvement in the equipment. Whether or not the technical advances will permit, economically, the establishment of a service providing for a facsimile newspaper in the home must await lifting of military censorship of the technical information. In addition, there is the question of whether the public desires such a service and, if so, at what price.

Though we have considered only the mass-entertainment services, it is believed that we may expect confidently a comparable growth in all the electronics applications which were in existence prior to the war. There also will be a great many new applications as a result of the war developments. These applications will concern such services as aviation, marine, and, in general, all communication work, but also will make their imprint on industry for such purposes as rectification, inversion, heating, instrumentation, control, inspection, sorting, and precipitation.

Lighting a British Underground Factory

WINDOWLESS factories have been built which depend entirely on artificial illumination, but unusual problems were encountered in the lighting of an underground factory producing airplane-engine components in Great Britain, according to an article published recently in *Electrical Review*, London. Areas of unusual dimensions and restricted mounting heights required special consideration in the selection and spacing of fixtures. The accompanying illustrations show the installations used to obtain several levels of intensity; Figures 1 and 2, sections with high-intensity lighting, Figure 3, medium-intensity; Figure 4, low-intensity.



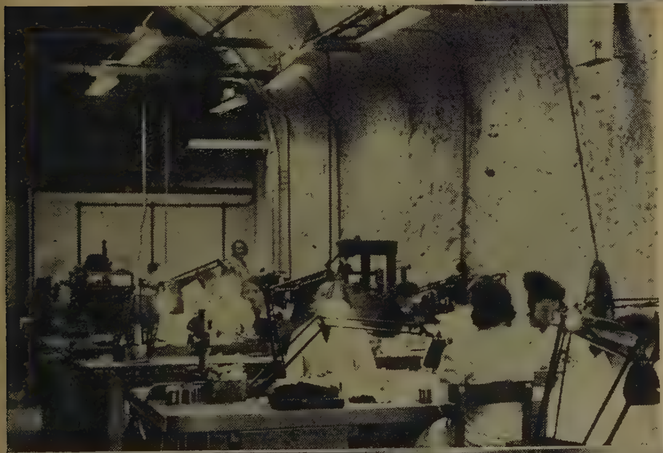
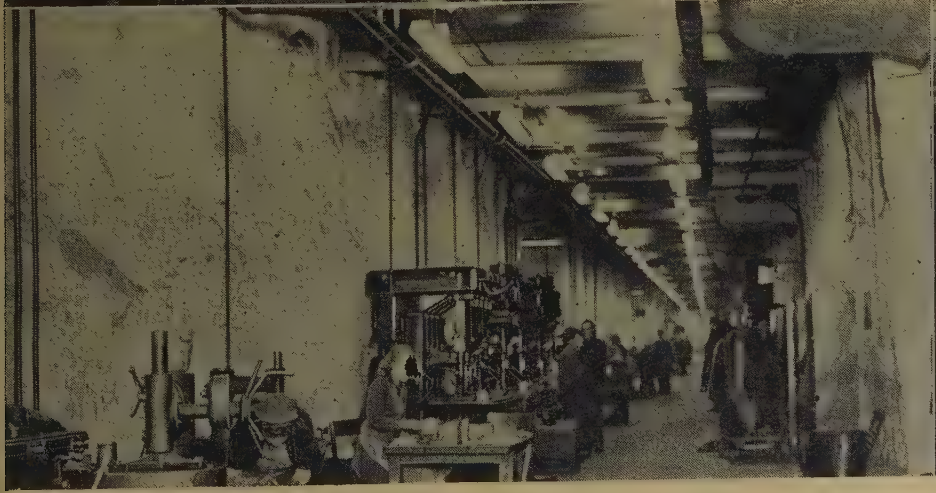


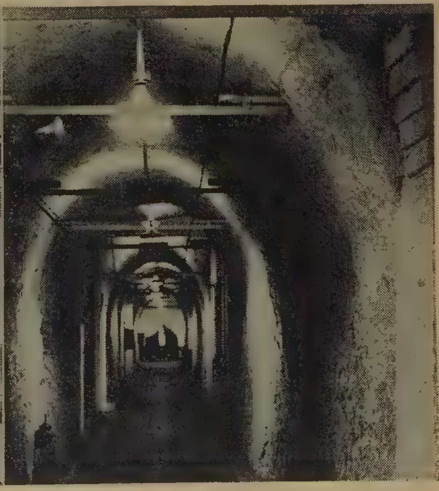
Figure 1 (left). Local lighting supplements general lighting from fluorescent fixtures in a bay 116 feet by 19 feet and provides 75–100 foot-candles for extra-fine inspection work

Figure 2 (above). Eighty-watt fluorescent lamps at a mounting height of seven feet provide 25 foot-candles at drawing-board level in an office

Figure 3 (left, below). A machine-tool section in a 16-foot-high corridor, 600 feet by 16 feet, is served by two lines o 80-watt fluorescent reflectors, with 40 in one line and 41 in the other; additional local lighting is provided at the machines

Figure 4 (below). A small corridor requiring only three to five foot-candles is lighted by 40-watt incandescent lamps





Papers Now Available for Discussion on AIEE Wartime Program

Nineteen technical papers now are available for discussion by mail as the Institute places in effect plans that have been devised to continue the preparation, discussion, and publication of papers while complying with wartime restrictions on meetings (*EE, Mar. '45, p 110*).

Abstracts of the papers that are available by mail in pamphlet form are given in the section immediately following. Pamphlets may be ordered at the prices shown from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y. Coupon books in five-dollar denominations are available for those who may wish this convenient form of remittance. A convenient order form is included in an announcement of the AIEE technical-program committee's "spring technical-paper program" that is being mailed to all AIEE members.

Discussion of the papers is invited and should be mailed in triplicate before the closing date of May 15, 1945, to C. S. Rich, secretary of the technical-program committee, AIEE headquarters, 33 West 39th Street, New York 18, N. Y. The papers and approved discussion ultimately will be published in AIEE *Transactions;* many of the papers, as determined by budget and paper limitations, will appear in *Electrical Engineering.*

ABSTRACTS • • • •

Air Transportation

45-85—Governor Requirements for Aircraft-Alternator Drives; *W. K. Boice (M '43), L. G. Levoy, Jr. (M '43). 25 cents.* The development of a-c electric systems for aircraft has given rise to a need for variable-ratio transmissions which can receive mechanical power from main aircraft engines and deliver it at substantially constant speed to a-c generators in spite of wide variations of engine speed. Governors for such drives require sufficient response to maintain generator speeds within close limits even during periods of engine acceleration and deceleration. Parallel operation of alternators has a pronounced influence on governor requirements. This paper presents the results of an analytical treatment of the problem of determining the governor response required during periods of engine acceleration. A method is described for calculating performance under a variety of conditions. Examples have been worked out which illustrate the nature of the phenomena involved and help to evaluate the relative importance of several design features and operating characteristics of transmissions and governors.

45-86—Selenium Power Rectifiers for A-C Aircraft Systems; *A. L. Embry (A '40). 15 cents.* To furnish the electric power required by modern large aircraft, a-c electric systems have been developed. Work has been done on two systems: one operating at constant frequency and the other with frequency varying as the main-engine speed. As considerable amounts of d-c power still are required in most cases, selenium rectifiers have been developed to supply this power from the a-c lines. In this paper are described three-phase rectifiers designed to provide regulated d-c power at 28.5 volts, using saturable core reactors and standard aircraft-type voltage regulators to control the output voltage. Rectifier units for both constant and variable-frequency systems are discussed, with current rating of 100 to 800 amperes.

45-87—400-Cycle Aircraft Motor; *G. O. Schwandt (A '39). 20 cents.* The ever-present need for lighter-weight and more compact aircraft electric motors is evident, since any reduction in weight or space provides increased fuel, bomb, or pay-load capacity. Reliable 400-cycle motors, more compact and lighter than existing 24-volt d-c motors, have been developed recently. Some of these motors are described in this paper. Also, the motor requirements and characteristics are discussed.

45-96—A 208-120-Volt 120-Ampere 400-Cycle Electrically Operated Aircraft Circuit Breaker; *C. H. Titus (A '40), P. J. Reifschneider (A '43). 15 cents.* With the selection of the 208-120-volt three-phase 400-cycle a-c system by the Army Air Forces for large aircraft, there has arisen the need for appropriate switchgear. In order to be applicable to the systems of such airplanes, switchgear must be able to perform its normal and emergency functions under the encountered conditions of temperature, pressure, humidity, vibration, and acceleration. This paper describes a 120-ampere remotely controlled electrically operated air circuit breaker designed for use as a bus-sectionalizing ring-tie or generator breaker on the 400-cycle grounded-neutral system. The interrupting rating of this breaker is 3,800 amperes at all pressures from sea level to 50,000 feet altitude. The closing solenoid and shunt trip have been designed to operate over a wide range of ambient temperature and control voltage. Being primary considerations in aircraft equipment, the weight and size of this breaker have been held to a minimum.

45-88—A Current-Limiting Fuse for Aircraft Applications; *A. H. Powell (A '43). 15 cents.* The capacity of aircraft electric systems has increased to a point where available fuses may not be satisfactory for the duty imposed on them. Furthermore, higher voltages are being used in order to transmit more power without using larger cables. A fuse is an ideal short-circuit protecting device, but it must be built properly and correctly applied. To meet the present and anticipated future requirements, a new current-limiting fuse has been designed for aircraft applications. This fuse, based on the well-known and time-tested design of high-voltage power fuses, has been built particularly for 208-120-volt three-phase 400-cycle applications and has an interrupting rating of more than 4,000 amperes. Tests have shown it is equally well suited for 120-volt d-c circuits requiring similar high interrupting capacities. The new fuse has been designed with the principal requirements of light weight, reliability, and reasonable life as major factors. Several departures from customary fuse designs have been necessary to accomplish the desired results. Steps followed in developing the new fuse and tests made in evolving and checking the new design are described along with a brief résumé of factors to be considered in applying and operating the fuse for most satisfactory results.

Electric Machinery

45-92—Per-Unit Impedances of Synchronous Machines; *A. W. Rankin (A '38). 20 cents.* This paper shows that rated stator kilovolt-amperes and voltage are not sufficient to determine all the per-unit impedances of a synchronous machine. It shows that the only impedances which can be given in terms of rated stator kilovolt-amperes and voltage are those which are measurable from the stator terminals and that all the internal machine impedances require the specification of some quantity in addition to the stator kilovolt-amperes and voltage before their per-unit value can be determined. Generalized per-unit formulas are developed, in which this additional quantity is given in terms of the selected rotor-circuit base currents. The use of these formulas will result in a consistent and consonant system of per-unit impedances.

45-93—A Generalized Circle Diagram for a Four-Terminal Network and Its Application to the Capacitor Single-Phase Motor; *J. G. Tarboux (F '43). 30 cents.* The main purpose of this paper is to present an operating circle diagram for the capacitor motor, showing that the input-current vector follows a circular envelope as the mechanical shaft power is varied. A secondary aim is to review the theory of the generalized four-terminal network, thereby developing circle-diagram equations which can be applied to any linear network which delivers its output power into a variable impedance of constant power factor. This generalized method of approach can be applied quite readily to the three-phase induction motor and the same results can be obtained, which are now available in practically all textbooks on a-c machinery. The same point of view can be extended to single-phase motors, the capacitor motor being a good example. Considerable work still remains to be done in order to make the single-phase circle diagram as useful as the one commonly used for three-phase motors, but the author feels that the generalized treatment offered in this paper may be a step in the right direction.

45-94—Winding-Fault Detection and Location by Surge-Comparison Testing; *G. L. Moses* (*M '44*), *E. F. Harter* (*A '42*). *15 cents.* Surge-comparison methods of testing insulation were investigated with the objective of locating as well as detecting faults. Experience of other investigators was confirmed, and limitations of methods and equipment were studied. Supplementary methods and equipment were devised to extend the field of usefulness of this basic type of tester, especially to the testing of very large machines with multiple-parallel windings. Apparatus studied included a-c motors from fractional-horsepower single-phase to very large three-phase types; a large variety of d-c armatures; and numerous armature, stator, and magnet coils. This surge-comparison tester has proved to be suitable for use by electrical manufacturers and by service and repair shops, as it can be used for testing most common types of electric windings.

45-95—Control of Electrical Insulating Varnishes; *D. L. Gibson* (*A '44*), *C. H. Braithwaite* (*A '45*). *15 cents.* The quality of the varnish film deposited depends upon the condition of the varnish in the processing tanks. Thickness of deposited-varnish films varies with viscosity and body. Heavy films interfere with coil sizes and increase problems of heat transfer. Thin films give inadequate protection. Conducting contaminating materials constantly are introduced into the tanks. These indicate close control of tank varnish is necessary for consistently high quality of apparatus treated. Methods of control are discussed, which include laboratory tests, physical tests, and a daily inspection of tanks. Portable cold-pressure filtering for removing much of the contamination present is described. Insulating varnishes are complex chemical mixtures, and care should be maintained in their use. It is important that they be under the control and supervision of persons with the proper training and experience. Constant quality control is necessary for satisfactory results.

45-97—Chemical Contamination as a Cause of Electrical-Insulation Failures; *C. H. Braithwaite, Jr.* (*A '45*), *G. L. Moses* (*M '44*). *15 cents.* Electrical-insulation failures were investigated and found to be caused by chemical contamination with ionizable materials. Examples of such contamination are certain types of hand creams, soldering fluxes, and germicides in lubricating oils. Contamination mechanisms often involve operations which are otherwise insignificant in manufacturing processes. The effect of these materials is reported on the electrical characteristics of the insulation. The need for close correlation of industrial hygiene, manufacturing processes, insulation design, and quality control is emphasized.

Instruments and Measurements

45-90—Basic Concepts of Moving-Magnet Instrument Rotors; *L. I. Mendelsohn* (*A '41*). *25 cents.* The performance of permanent-magnet instrument rotors is rationalized on the basis of electromagnetic theory. Procedures are given for predicting this performance and for selecting the material best adapted to the operating conditions. By analysis of the magnetic behavior of rotors of elliptic-spheroid shape immersed in a uniform field, their intrinsic induction, their magnetic moment, and the mechanical torque which they will produce are determined. The elliptic-spheroid shape serves as a good approximation of most practical instrument rotor designs.

45-100—Precision Testing of Electric Tachometers; *M. A. Princi* (*M '45*). *15 cents.* The magnetic-drag electric tachometer which was developed especially for the measurement of aircraft-engine speed is inherently a more precise measuring device than those instruments which normally have been used as reference standards of speed measurement. This paper describes an electric-tachometer testing system which meets the requirements of high accuracy and is also suitable for large-quantity manufacture of tachometers. The system provides facilities for testing at 22 scale points in a range of speeds from 500 to 4,500 indicated rpm without referring to a standard instrument. The power to drive the tachometers being tested is supplied from tachometer generators, which are driven by a d-c motor controlled by a precision tuning fork. The method of operation and the control system are explained.

45-101—Analysis and Design of a D-C Selsyn System; *Joseph Manildi. 20 cents.* In this paper the author presents a rigorous analysis of a conventional d-c Selsyn remote-indicating system. The first part of the analysis shows that a natural error exists in the system, which has a 60-degree cycle and which reaches a maximum value of 1.1 degrees. The error is zero at each 30-degree point and reaches a maximum almost midway between the 30-degree points. The natural error of the Selsyn system arises from the fact that the transmitter resistance is a linear function of the transmitter angle θ. This natural error may be overcome by designing a transmitter resistance in a nonlinear manner. The equation is developed for the necessary variation of the transmitter resistance with the transmitter angle. Furthermore, the shape of the toroid on which this resistor should be wound to give this desired variation is derived therefrom. The paper further presents optimum values of resistances for both transmitter and receiver, in order that the greatest amount of torque may be transmitted to the receiver for a given amount of power.

Land Transportation

45-83—Measurement of Railway-Motor Temperatures in Service; *J. W. Teker* (*A '31*). *20 cents.* The question of operating temperatures of Diesel-electric-locomotive electric equipment is of more than academic interest; it is an active factor exerting its influence with time on the life of the equipment and is worthy of economic consideration. The application of motive power to a given duty can be made correctly only with full knowledge of resulting apparatus temperatures. Application studies may be difficult at times, when variables of uncertain magnitudes are encountered. However, temperatures can be measured in actual service accurately and quickly by using the recognized resistance method properly adapted to the conditions encountered in railway operation. The technique and equipment developed to meet these conditions and perfected by experience in actual practice provide a means of obtaining temperature data, valuable to railroad operating and motive power departments, as well as for the application and design engineer.

45-84—Dynamic Braking With Traction Motors; *L. G. Riley, G. M. Woods* (*M '43*). *15 cents.* Retardation with traction motors, either independently or as an adjunct to mechanical braking, has been utilized in various forms on practically all types of electric vehicles from battery trucks to main-line locomotives. In some cases, it is used only to maintain uniform speeds on long grades and in others to make regular service stops. While the general principles are nearly as old as the electric-traction industry itself, in recent years numerous refinement have greatly extended the usefulness of dynamic braking by affording improved performance, additional safety, and simplification of mechanical braking systems. This paper discusses the various means by which favorable results have been accomplished, with a minimum amount of additional electric equipment.

45-91—Rewinding Commutator-Type Traction Armatures; *N. J. Greene* (*M '45*), *D. E. Stafford* (*A '37*), *C. Gentilini* (*A '32*). *25 cents.* With the increased number of electric locomotives in use, the longer hours of operation, and the heavier loads, old maintenance problems have been accentuated; new ones have arisen. The object of this paper is to review for those experienced in the art of armature rewinding and to cite for the newcomer some of the important and frequently overlooked factors which must be considered in restoring a damaged armature to its original condition and in modernizing and improving consistently with current practices. The factors are discussed under the following headings:

1. Analysis of failure.
2. Cleaning.
3. Magnetic inspection.
4. Commutator.
5. Rewinding materials.
6. Armature windings.
7. Banding.
8. Impregnating.
9. Balancing.

Railway armatures present an interesting though difficult problem, since they must withstand the severe strains imposed upon them by varying loads at varying speeds, plus the several combinations of vibration and strains resulting from train motion and roadbed shock, often with rapidly changing ambient temperatures.

Akron Section inspects the new Gorge power plant of the Ohio Edison Company, Akron Ohio, on the occasion of the Section's first meeting of the 1944–45 season

Quality Control

45-89—Statistical Methods Applied to Insulator Development and Manufacture; *AIEE subcommittee on application of statistical methods. 15 cents.* This paper has been written for engineers who are, like the author, amateurs in the application of statistical methods. It illustrates by examples taken from the field of high-voltage-insulator manufacturing, certain types of problems that benefit by statistical treatment. Only a passing reference is made to quality control of product, since studies of this subject are readily available. Particular attention is called to significant patterns in the distribution of test observations and to physical causes that nonnormal patterns may imply. Since in destructive testing two distinct tests cannot be made on a single specimen, statistical analysis is almost indispensable for the correlation of product characteristics. As an example of such an inquiry, the relationship between short-time and time-load tests is explored by statistical methods. Other sections of the paper discuss the relationship between quality control and routine testing of product, and the limitations of sampling as a means of determining product characteristics.

45-99—Statistical Tools for Controlling Quality; *Joseph Manuele (M '44), Casper Coffman. 20 cents.* The application of mathematical statistics for controlling the quality of products gives the manufacturer three tools:

1. The frequency distribution enables him to determine, very soon after production has started, what the quality of the product is likely to be.

2. The control chart enables him to detect variations in statistical control, so that he can take corrective measures to avoid producing products which will fall outside of specification limits.

3. Analysis of variance enables him to check for significant differences between parts produced by different tools.

45-98—Application of Quality Control to Resistance Welding; *L. S. Hobson (M '39), R. S. Inglis, R. P. McCants. 15 cents.* Quality control has been applied successfully to resistance welding in the fabrication of electric switchgear. The methods of testing and control have been in use for over two years and give assurance of uniform weld quality. Standardization of the process is essential to its control. Standard tables covering machine settings for all combinations of materials normally used in switchgear structures make possible uniform welding practice in the shops. Welded specimens are prepared each hour under the same conditions of production welding. These specimens are tested in torsion in special testing machines to determine ultimate torque, angle of twist, and weld diameter. These factors are combined to give a quality number or index. Averages are plotted on a control chart posted on each machine. Weekly reports are issued showing the performance of each machine and the over-all control of the process. Resistance welding, properly controlled, becomes a safe dependable fabrication process.

AIEE Executive Committee Meets at Headquarters

A transfer of Section territory, approval of recommendations of the Standards committee, and confirmation of proposed joint activity for the AIEE were among the matters considered at the meeting of the executive committee held February 27, 1945, at Institute headquarters.

Upon recommendation of the Standards committee a revision, prepared by the committee on automatic stations, of "American Standard for Automatic Stations, C37.2" AIEE Standard 26 was approved, for submission to the American Standards Association. The following were adopted for publication: Final revision, prepared by a subcommittee of the committee on electric machinery, of the "Test Code for Synchronous Machines," which has been available in pamphlet form as a report since January 1937; final revision, by the committee on protective devices, of the report on "Standards for Fuses Above 600 Volts," which has been available in pamphlet form as a report since July 1941; report of the Joint AIEE–ASME Committee on Turbogenerators on "Proposed Preferred Standards for Large 3,600-Rpm Three-Phase 60-Cycle Condensing-Type Turbogenerators."

An appropriation was made for a second printing of the report on "Electric Power Distribution for Industrial Plants" as the small number of copies remaining in stock is insufficient to meet the demand.

Upon approval of the Sections concerned and the vice-presidents of Districts 5 and 2, and upon recommendation of the Sections committee, it was voted to transfer Auglaize County, Ohio, from the Fort Wayne Section in District 5 to the Dayton Section in District 2.

AIEE subscription to the Canadian Radio Technical Planning Board was authorized, as recommended by W. J. Gilson (M '38) vice-president of the Canada District. (The Institute became a contributing sponsor of the Radio Technical Planning Board in the United States in October 1943.)

Pursuant to the action of the board of directors in January in referring the matter to the executive committee for action, it was voted that the Pacific Coast technical meeting scheduled to be held in Seattle, Wash., in August 1945 be postponed to 1946.

The technical-program committee and the committee on electronics were authorized to take such part as may be desirable in the electronics conference scheduled to be held in Chicago, Ill., on a local basis in 1945, of which the Chicago Section of the AIEE will be a sponsor.

F. A. Cowan (M '29) chairman of the technical-program committee, reported on plans of the committee for continuing the technical-program activities of the Institute during the cessation of meetings (see page 156 of this issue). The plans were approved.

In view of the cancellation of the 1945 summer technical meeting, during which the annual business meeting of the Institute would have been held and the board of directors' action in January in referring to the executive committee decision on time and place of the annual meeting, a resolution was adopted that the 1945 annual business meeting be held at AIEE headquarters New York, N. Y., on Wednesday, June 27.

To fill the unexpired terms of the late H. L. Huber, J. J. Pilliod (F '34) was appointed an alternate representative of the Institute on the Standards Council of the American Standards Association for the unexpired term, ending December 31, 1945, and a representative on the electrical standards committee of ASA to fill the unexpired term, ending July 31, 1945.

Three members of the Institute were designated to represent the AIEE at the annual meeting of the American Academy of Political and Social Science in Philadelphia, Pa., April 13–14, 1945, namely: C. H. Black (A '41), N. E. Funk (F '34), and I. M. Stein (F '39), all of Philadelphia.

Present at the executive committee meeting were:

C. A. Powel, *chairman;* P. L. Alger, J. F. Fairman, W. R. Smith; H. H. Henline, national secretary; F. A. Cowan, chairman of the technical-program committee (during discussion of plans of that committee).

Recommendations adopted by the board of examiners at a meeting held February 15, 1945, were reported and approved. Upon recommendation of the examiners, the following actions were taken: seven applicants were transferred to the grade of Fellow; 34 applicants were transferred and 38 were elected to the grade of Member; 189 applicants were elected to the grade of Associate, and one Associate was reinstated; 177 Student members were enrolled.

Subcommittee on Statistical Methods Announces Year's Program

Preparation of a series of short articles on statistical methods which will appear in *Electrical Engineering* beginning next month is part of the program for the year announced by the subcommittee on statistical methods of the AIEE Standards committee. The subcommittee, appointed in October 1944, held a conference during the recent AIEE winter technical meeting (*EE Mar '45, pp 117–18*).

The activities announced by the subcommittee are as follows:

1. An educational program including

(*a*). A series of short technical articles developing the subject from first principles.

(*b*). Articles describing special applications of statistical methods.

(*c*). The sponsoring of the presentation of papers at Section meetings; also the sponsoring of technical conferences and sessions at District and national meetings when these are resumed.

(*d*). General articles addressed primarily to executives, pointing out the advantages of statistical methods.

2. A study of applications in Institute test codes and Standards.

3. Applications in the electrical utilities' field.

4. Co-operation with Doctor Shewhart's Joint Committee on Applications of Statistical Methods in Engineering and Manufacturing.

5. Keeping in touch with developments in which the Institute might properly co-operate.

The work of the subcommittee is described by W. P. Dobson, chairman, as follows:

While statistical methods have been applied in industry for many years, their use has been extended widely since the beginning of the war. The necessity of providing war materials in vast quantities under exacting tolerance requirements naturally directed attention to quality control of items produced by mass-production methods. The methods developed in the Bell Telephone Laboratories through the pioneer work of Walter A. Shewhart have found extensive applications in American and British industries and have aided the war effort tremendously by effecting improvement in quality, increased production, and reduction in costs.

The Office of Production Research and Development and the United States Office of Education have added impetus to the interest thus aroused by organizing in co-operation with universities intensive courses of training in statistical quality control. The National Research Council has set up committees covering the whole field; one of these, under the chairmanship of Doctor Shewhart is the Joint Committee for the Development of Statistical Applications in Engineering and Manufacturing. In October 1944 AIEE accepted an invitation from Doctor Shewhart to participate in the work of his committee.

In view of the widespread interest in the subject and of the fact that the Institute had not given much attention to it previously, the Standards committee at its meeting in October 1944 appointed a subcommittee to explore the possible applications in the Institute's field and to ascertain the reaction of the membership. As a first step a conference was held at the winter meeting in January. The large attendance and comprehensive discussion of the conference papers provided convincing evidence of a keen interest among the Institute membership and was of great assistance to the subcommittee in preparing its plans for the coming year.

EDUCATION PROGRAM

The primary obligation of the subcommittee appeared to be the dissemination of information about statistical methods as widely as possible among the membership of the Institute, including the essential theory and the technique of application. Most of the articles which have appeared in the Institute's publications have presupposed a knowledge on the part of the reader which is possessed only by experts, and have been criticized on the ground that they were difficult to read because of the unfamiliar technical terms used and lack of detailed explanation of the various steps in the reasoning. Most electrical engineers have not received instruction in the theory of probability and its applications, and, while excellent textbooks are available and the literature of the subject is extensive, it may appear to the interested engineer a formidable task to acquire the necessary knowledge in order that he may apply the methods in his work. This is not the case; it is not necessary to have a thorough understanding of statistical theory or a knowledge of advanced mathematics in order to apply the control techniques.

An adequate foundation may be laid without mastering the contents of a voluminous textbook.

It therefore appears appropriate to give the Institute membership the opportunity of acquiring the necessary fundamental knowledge without an undue expenditure of time. A small group of experts has been appointed to prepare a series of papers for publication in *Electrical Engineering*. These articles will develop the subject from first principles and will lay a foundation for further study and for an understanding of specialized articles of an advanced character. They will be short and will form a series beginning in the May issue. Carefully prepared bibliographies will be included to guide readers who may desire to make a more extensive study. The subcommittee invites those having special experience to submit articles on special applications.

CONFERENCES AND SESSIONS

The maximum benefit in the development of any subject results from discussion. The subcommittee therefore proposes to the Sections that they consider the inclusion of papers in their programs for the coming year and offers its assistance in suggesting subjects and speakers.

INSTITUTE TEST CODES AND STANDARDS

The principal term of reference in the instructions to the subcommittee was the application of statistical methods in Institute test codes and Standards. The educational program is a stepping stone to this final goal. It is designed to lay a foundation of knowledge and to arouse an interest in the membership generally and in the technical committees, so that the way may be prepared for co-operation between them and the subcommittee in the study of these applications. Progress will depend upon careful study and close analysis of all factors. As a beginning it has been suggested that the aircraft field, one of the most recent activities undertaken by the Institute, may provide a subject, and aircraft generators and motors have been chosen. A group has been formed containing representatives from the subcommittee for aircraft electric rotating machinery and the subcommittee on statistical methods to study this question.

APPLICATIONS IN UTILITIES FIELD

Although at the present time quality control in production is of paramount interest, statistical applications in inspection by purchasers are important. Reduction in inspection costs with maintenance of quality are of importance to the utilities who are large purchasers. Sampling by the purchaser is a fundamental factor and should be correlated with production control methods. This will be given attention. Other applications in the utilities' field will be given attention as the opportunity arises.

GENERAL

Doctor Shewhart's committee will provide a forum wherein the Institute may join with other national societies and assist in securing the maximum co-operation and the ideal correlation of their various activities.

CONCLUSION

The program sketched herein is an ambitious one, and it is obviously impossible under present conditions to carry forward all the projected activities in the immediate future. The most pressing war needs demand first attention, but the impetus given to the subject by the war without doubt will result in a continued expansion of statistical applications in the postwar period. The Institute has a vital interest in giving leadership to its members and assistance to industry and the public, to the end that all elements of the electrical industry and of the profession may play their part most efficiently.

The personnel of the subcommittee of the Standards committee is as follows:

M. M. Brandon, Underwriters Laboratories, New York, N. Y.

H. F. Dodge, Bell Telephone Laboratories, New York, N. Y.

C. M. Gilt, Consolidated Edison Company of New York, New York, N. Y.

L. S. Hobson, General Electric Company, Philadelphia, Pa.

J. Manuele, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

A. I. Peterson, Radio Corporation of America, Camden, N. J.

W. P. Dobson, Hydro-Electric Power Commission of Ontario, Toronto, Canada (chairman).

SECTION • • • • • •

Engineers in Sacramento Form AIEE Subsection

With a nucleus of only eight Institute members resident in the area, a Sacramento (Calif.) Subsection of the San Francisco Section has been organized following four trial meetings initiated last November. Officers have been elected with W. E. Camp (M '22), consulting engineer, as chairman and E. A. McGinty, Pacific Gas and Electric Company, as secretary–treasurer, and a regular series of monthly meetings has been programmed.

It was decided to attempt organization of a Subsection when it was realized that a large number of engineers in the region might be interested in joining the Institute, provided local meetings could be held. As a result, a Subsection committee under the chairmanship of W. A. Lindblad was appointed with membership drawn from members and nonmembers in Sacramento. The local committee set up a mailing list of approximately 150 engineers and, in addition, had posters placed on bulletin boards in plants and offices announcing the first meeting which subsequently boasted an attendance of 172, including a representative group from San Francisco.

The Sacramento Subsection is operated through funds provided by the San Francisco Section. Its program for the coming year will offer speakers drawn from Section membership, and an endeavor is being made to secure the services of visiting speakers also.

PERSONAL • • • • •

F. A. Lewis

W. R. MacDonald, Jr.

F. A. Lewis (A '31, M '35) acting editor of AIEE publications since 1942, has resigned to become vice-president of the Hooton Chocolate Company, Newark, N. J. Born in Carverton, Luzerne County, Pa., January 20, 1903, Mr. Lewis was graduated from Syracuse University in 1926 with the degree of electrical engineer. At once he became associated with the Consolidated Edison Company of New York (N. Y.), Inc., and from 1926 to 1929 served in the test department. In 1929 he was transferred to the transmission and distribution department. During 1930 and 1931 he was engaged in magnetic research work as a member of the technical staff of Bell Telephone Laboratories, Inc., New York. From 1928 to 1931 he taught industrial mathematics in the evening school of Pratt Institute, Brooklyn, N. Y. Mr. Lewis joined the AIEE editorial staff in 1931 as assistant editor, and in 1936 he became associate editor. He is a member of Tau Beta Pi and Pi Mu Epsilon, and is currently serving as a member of the executive committee of the New York Business Paper Editors.

W. R. MacDonald, Jr. (A '33, M '44) AIEE assistant editor, has been appointed acting editor. He was born August 22, 1910, in New York, N. Y., and received the degree of electrical engineer from Cornell University in 1932. After his graduation he established and operated a radio service and repair business until in 1934 he joined the AIEE editorial staff. In 1938 he was named an assistant editor. Mr. MacDonald, who had been commissioned a second lieutenant in the Signal Corps Reserve of the United States Army in 1932, was called to active duty as a first lieutenant in 1941. He was assigned to the Office of the Chief Signal Officer in Washington, D. C., as head of the literature subsection, military training branch, and in this position he was responsible for the preparation of field and technical manuals for the Signal Corps. He was successively promoted to the ranks of captain and major. In 1944 he was released from active duty, and he returned to the Institute's editorial staff. Mr. MacDonald originally was employed by AIEE during the period of a major change in publication policy and while the May 1934 50th anniversary issue of *Electrical Engineering* was under preparation. His many contributions have been of material assistance in the subsequent maintenance and development of the Institute's publication services. He is a member of Eta Kappa Nu and a fellow of the Radio Club of America.

N. B. Hinson (A '19, F '35) formerly chief engineer, Southern California Edison Company, Ltd., Los Angeles, has been elected vice-president and executive engineer of the company. Mr. Hinson joined the company then known as the Edison Electric Company, as testman in 1906. He was transferred to the distribution department in 1912 and named distribution engineer in 1913 and assistant superintendent of distribution in 1920. He became system planning engineer in 1923, assistant manager of operation in 1928, and chief engineer in 1934. **H. W. Tice** (A '34) formerly manager of operation, for the Edison Company also has been elected a vice-president of the company and will continue to direct operation. A graduate of Lehigh University, Mr. Tice, who became associated with the Edison Company in 1922, previously had been employed in steel manufacturing in Pennsylvania, South America, and Cuba. He was made operating engineer in 1927, assistant manager of operation in 1937, and manager in 1941. **W. E. Row** (A '39) formerly assistant manager of operation, succeeds Mr. Tice. He was first employed by the company from 1908 to 1915 at construction and distribution engineering work. After employment in Shanghai, China, from 1915 to 1921 as a manager of engineering for the Fobes Company, Ltd., he returned to the United States and after brief employment with the California Railroad Commission entered the distribution department of the Edison Company, becoming distribution engineer in 1927. He was made assistant superintendent of distribution in 1936 and assistant manager of operation in 1942.

W. L. Chadwick (M '38) formerly chief civil engineer of the operating department, has been appointed manager of the engineering department. A graduate of the University of Redlands, Mr. Chadwick joined the Southern California Company in 1928 as transmission engineer. From 1931 to 1937 he was employed as engineer and senior engineer on construction of the Colorado River aqueduct for the Metropolitan Water District of Southern California. Returning to the Edison Company in 1937, he was given charge of civil engineering. **W. N. Johnson** (A '22, M '30) formerly superintendent of distribution, replaces Mr. Row as assistant manager of operation. Mr. Johnson was connected with the Bureau of Power and Light of the City of Los Angeles before joining the Edison Company about 1932. A former manager of the company's Vernon City district, he has been superintendent of distribution since 1941. **L. F. Hunt** (A '21, F '38) formerly senior engineer in the operations department, has been appointed chief electrical engineer. Mr. Hunt, who holds the degrees of bachelor of science (1919) and electrical engineer (1929) from the University of Southern California commenced his career with the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., for which he designed many types of protective relays from 1919 to 1922. He became assistant to the protection engineer of the Edison Company in 1922, development engineer in 1924, and protection engineer in 1930. In 1941 he was named senior engineer. He is the author of numerous technical articles and holds a number of patents for protective devices.

J. D. Enefer (A '43) engineer, has been made assistant to the manager of the engineering department. Mr. Enefer has been with the company since 1917 as operator, substation chief, division superintendent, and engineer.

C. T. Malloy (A '35) formerly superintendent of transmission and communication, has been named general superintendent of those departments. Mr. Malloy entered the company employ as a clerk in 1922 and later became patrol supervisor and assistant superintendent of transmission. **R. N. Coe** (A ’42) formerly superintendent of underground, has been appointed assistant superintendent of distribution. He has been with the Edison Company since 1938.

T. F. Barton (A ’12, F ’30) of New York, N. Y., **W. O. Batchelder** (A ’08) of Chicago, Ill., **L. T. Blaisdell** (A ’20, F ’39) of Cleveland, Ohio, **W. B. Clayton** (M ’40) of Dallas, Tex., **E. H. Ginn** (A ’03) of Atlanta, Ga., **A. L. Jones** (A ’07, F ’38) of Denver, Colo., **T. S. Knight** (A ’05) of Boston, Mass., and **A. S. Moody** (A ’09) of Portland, Oreg., all commercial vice-presidents, General Electric Company, Schenectady, N. Y., have relinquished their responsibilities for apparatus sales in their respective districts to become members of the president’s staff for the purpose of furthering better customer relations. **C. W. Fick** (A ’16, F ’39) formerly district engineer, Cleveland, has been made district manager of apparatus sales for the company’s East Central district. Mr. Fick joined the General Electric Company soon after his graduation from the University of Illinois in 1912. He was stationed in Schenectady and in Portland, Oreg. before his transfer to Cleveland. **R. I. Parker** (A ’14, M ’20) district manager, Chicago, has been made manager of apparatus sales for the district. Mr. Parker entered the employ of the company in Schenectady in 1912, the year of his graduation from the University of Kansas, and in 1913 was transferred to Chicago. **H. A. White** (A ’40) district manager of the industrial department, Dallas, has been made district manager of apparatus sales. Mr. White has been with the General Electric Company since his graduation from the University of California in 1915 and has had his headquarters in Dallas since 1917.

F. H. Doremus (A ’24, M ’32) manager of the industrial department in Denver, has been made manager of apparatus sales for that district. Mr. Doremus, who was graduated from the University of Nebraska in 1922, joined the General Electric Company in Schenectady and in 1925 was sent to Denver. **A. G. Jones** (A ’07) district manager of the central station transportation department, San Francisco, Calif., has been made manager of apparatus sales. A 1904 graduate of Alabama Polytechnic Institute, Mr. Jones has been with the General Electric Company since 1905 and in San Francisco since 1908. **H. E. Dunham** (A ’09, M ’39) formerly assistant manager, patent department, Schenectady, has been appointed manager. Mr. Dunham was graduated from Syracuse University in 1906 and received his law degree from George Washington University in 1913. He joined the General Electric Company in 1912 and has been assistant manager of the patent department since 1930. **H. M. Sliter** (M ’43) formerly assistant district manager of the central station division, New York, has been appointed district manager of the division. Mr. Sliter was graduated from Cornell University and entered the test department in 1908. In 1927 he was transferred to the New York district office. **R. M. Darrin** (A ’28, M ’34) formerly manager of the company’s Syracuse, N. Y., office, succeeds Mr. Sliter. A graduate of Amherst College, Mr. Darrin has been in the company employ since 1919 and has managed the Syracuse office since 1940.

J. R. Read (A ’04) chairman and president, Canadian Westinghouse Company, Ltd., Hamilton, Ontario, has been elected to the board of directors of the Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa. Mr. Read who has been president of the Canadian Company since 1939 and chairman since 1944, entered the employ of the Canadian Westinghouse Company in 1904 and before that had been employed by the Westinghouse company in Pittsburgh. **J. T. Mathews** (A ’35) formerly engineering representative, Westinghouse International Company, Buenos Aires, Argentina, has been appointed assistant manager of the foreign engineering department, Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa. Mr. Mathews, a 1927 graduate of the University of British Columbia, joined the Westinghouse organization in 1927 and the foreign engineering department in 1934. His work for the department has taken him to France, Germany, and England as well as Argentina.

C. R. Reid (A ’08, F ’44) superintendent of the Shawinigan Water and Power Company, Montreal, Quebec, Canada, has retired. Mr. Reid received the degrees of bachelor of science in 1906, and master of electrical engineering in 1912 from the University of Oregon and the degree of master of mechanical engineering from Cornell University in 1916. He had been employed by the Shawinigan Company since 1916 as electrical engineer, power house superintendent, assistant general superintendent, and after 1937 as general superintendent. Mr. Reid plans to open a private business in California. **W. R. Way** (M ’42) formerly assistant general superintendent of the company, succeeds Mr. Reid. A 1918 graduate of McGill University, Mr. Way entered the employ of the company that same year as general engineering assistant. He was appointed chief system operator in 1924, superintendent of operation in 1935, and assistant general superintendent in 1940. **J. M. Sharpe** (A ’27, M ’44) formerly system operating engineer, has been appointed superintendent of the system operating division of the company. Mr. Sharpe was graduated from McGill University in 1925 and immediately afterwards joined the Shawinigan Company. **E. W. Knapp** (A ’31, M ’44) formerly acting head of the engineering division, has been appointed superintendent of the engineering division. Mr. Knapp, who is a 1923 graduate of McGill University, entered the employ of the Shawinigan Company in 1925. **A. L. Hough** (M ’43) formerly assistant superintendent of distribution stations, has been appointed superintendent of substations division. Mr. Hough was employed by the Shawinigan Company from 1922 to 1928 and, after his graduation from McGill University in 1933 returned to its employ.

L. G. Dandeno (A ’18, M ’44) formerly superintendent of the Thunder Bay system of the Hydro-Electric Power Commission of Ontario, Cameron Falls, Canada, has been appointed superintendent of the Eastern Ontario division of the Southern Ontario system. Mr. Dandeno joined the Ontario Commission after his graduation from the University of Toronto in 1916 and has been superintendent of Thunder Bay since 1923. **J. W. Looney** (A ’32) superintendent for the Commission at Fitzroy Harbour, will succeed Mr. Dandeno. Mr. Looney has been with the Commission since 1930, the year he graduated from the University of Toronto. **L. H. Baxter** (A ’26) formerly meter engineer in Toronto, Ontario, will fill the superintendency vacated by Mr. Looney. Mr. Baxter, who also is a graduate of the University of Toronto (1924), has been employed by the Commission since 1923.

J. H. Belknap (M ’34) lieutenant colonel on duty with the United States Army Air Forces, Washington, D. C., has been appointed chairman of the newly established division of engineering of the University of Rochester, N. Y. Colonel Belknap will be Yates professor of electrical engineering. A 1912 graduate of Oregon State College, Corvallis, Colonel Belknap taught at that institution, except during World War I, until 1923. He was associated with the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., from 1923 until in 1942 he was commissioned a major in the Air Corps to serve as a member of the AAF Officer Appointment Board. He is a member of the laboratories of the National Advisory Committee for Aeronautics and has received a commendation from General Ira Eaker for his work as a member of a special military mission to the United Kingdom.

Zay Jeffries (M ’36, F ’42) vice-president in charge of the chemical department of the General Electric Company, Pittsfield, Mass., is the first recipient of the newly established annual powder metallurgy medal of Stevens Institute of Technology, Hoboken, N. J., for “outstanding work in the field of powder metallurgy.” Doctor Jeffries also has just been awarded the Francis J. Calmer Medal of the Franklin Institute which is given once every five years for achievement in the field of metallurgy for his “meritorious contributions to the science of metals, which he has placed on a new and more intelligent basis.”

R. E. Blasen (A ’34) recently retired as lieutenant colonel in the United States Army Corps of Engineers, has been appointed application engineer for the San Diego, Calif., area by the Westinghouse Electric and Manufacturing Company. A 1933 graduate of Oregon State College, Mr. Blasen joined the Westinghouse Company in 1936 and after assignments in East Pittsburgh, Pa., and in Seattle and Spokane, Wash., was transferred to Los Angeles, Calif., in 1940. He entered active service as a first lieutenant in 1941 and participated in the North African, Sicilian, and Italian campaigns.

N. A. Rollins (M ’27, F ’40) staff engineer, engineering department, Commonwealth Edison Company, Chicago, Ill., recently retired. Mr. Rollins attended New Hampshire College and in 1904 entered the employ of the Edison Company as a draftsman. He was made field engineer in 1927 and in 1935 as plant installation engineer was put in charge of the installation of all the station, substation, and outside plant equipment for the company. He became staff engineer in 1943.

A. M. Garrett (A '22, M '40) staff engineer, engineering department, Commonwealth Edison Company, Chicago, Ill., recently retired. Mr. Garrett received the degree of bachelor of science in electrical engineerng from Purdue University in 1904 and was employed by the Commonwealth Edison Company as a draftsman in 1907. Progressing through various design and construction duties he became a field engineer in 1927 and as such was in charge of substation design and installation. In 1937 he was named staff engineer.

V. M. Marquis (A '23, M '31) formerly of the engineering department of the American Gas and Electric System, New York, N. Y., has been named director of the Office of War Utilities' power division. Mr. Marquis was graduated from Stanford University in 1921 and received the degree of master of science from Union College. He was associated with the General Electric Company, Schenectady, N. Y., until 1927 and had been with the American Gas and Electric System since 1928.

C. R. Hanna (A '24, M '39) formerly manager of the electrochemical department, research laboratories, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has become an associate director of the laboratories. Mr. Hanna, who holds two engineering degrees from Purdue University, entered the research department of the Westinghouse Company in 1922 and became manager of the development division in 1923 and of the electromechanical division in 1930.

F. X. Lamb (A '36) formerly development engineer, electrical-engineering department, Weston Electrical Instrument Corporation, Newark, N. J., has been made assistant chief electrical engineer. Mr. Lamb joined the Weston Corporation in 1921, and in 1928 organized and became head of the commercial division of the engineering department. In 1937 he went to the Orient as resident engineer, returning and becoming division chief in 1939 and project engineer in 1942.

Edward Allen (A '40) formerly editor, *Electric Light and Power*, Chicago, Ill., has been appointed general service engineer, Electric Power Board of Chattanooga, Tenn. Mr. Allen was graduated from Louisiana State University in 1925 and after an association with the Public Service Company of Northern Illinois, Chicago, joined *Electric Light and Power* as engineering editor in 1937. Since 1940 he had been editor in chief.

M. E. Bretschneider (A '32, M '39) formerly foreman of the laboratory, Kansas City (Mo.) Power and Light Company, has been made assistant superintendent of meters and laboratory. **Clarence Sloan** (A '41) of the company's laboratory will succeed as foreman. **K. W. Koso** (A '32) formerly foreman of electrical maintenance, has been appointed assistant electrical engineer of power plant.

E. S. Coffman (A '34) formerly senior engineer, bureau of electrical engineering, Federal Power Commission, Washington, D. C., has been appointed chief of the division of rates and research. Mr. Coffman was associated with the Public Service Commission of Indiana and the Power Authority of the State of New York before joining the Federal Power Commission in 1933.

H. B. Marvin (A '20, M '43) formerly assistant engineer, in the general engineering laboratory of the General Electric Company, Schenectady, N. Y., will be responsible for special assignments in the company's tube division of the electronics department. Mr. Marvin, who holds the bachelor's and master's degrees in electrical engineering from Union College, has been associated with the company since 1915.

V. G. Muzsnay (A '38) associate engineer, Northeastern inspective district, Bonneville Power Administration, Schenectady, N. Y., has been appointed electrical engineer, consultant, and technical adviser for the Administration's Puget Sound district office. Mr. Muzsnay, who was born and educated in Czechoslovakia, formerly was chief electrical-engineering draftsman for the Fourth Naval District, Philadelphia, Pa.

L. P. Haner (A '41) formerly engineer in the rayon pioneering research section of E. I. du Pont de Nemours and Company, Buffalo, N. Y., has been transferred to the rayon engineering section of the company to establish an electronics group. Mr. Haner, who graduated from the University of Washington in 1937, has been with the du Pont Company since 1939.

John Hutchings (A '36, M '43) chief engineer, Continental Electric Company, Geneva, Ill., has been appointed vice-president in charge of engineering. After his graduation from the University of Nebraska in 1933, he joined the General Electric Company, Schenectady, N. Y., in 1934. In 1942 he became chief engineer of the Continental Electric Company.

A. G. L. McNaughton (A '11, HM '42) recently named a Canadian Defense Minister and formerly lieutenant general and commander in chief of the Canadian Active Service Forces, has been promoted to the rank of full general and retired from the Canadian Army. General McNaughton is the fourth Canadian to be honored with this rank.

R. G. Slauer (A '41) formerly in the commercial engineering department of the lamp division of the Westinghouse Electric and Manufacturing Company, Bloomfield, N. J., has become manager of the application laboratory of Sylvania Electric Products Inc., Salem, Mass. Mr. Slauer had been associated with the Westinghouse Company since 1930.

R. B. Lattin (A '36) formerly factory manager, Rockbestos Products Corporation, New Haven, Conn., has been appointed technical director. Mr. Lattin, who joined the company as research engineer in 1932, previously had been associated with the Johns Pratt division of the Colts Patent Fire Arms Manufacturing Company, Hartford, Conn.

W. F. Hess (A '32, M '41) associate professor and head of the welding laboratory, Rensselaer Polytechnic Institute, Troy, N. Y., has been awarded the Lincoln Gold Medal of the American Welding Society in conjunction with W. C. Herrschaft as the authors of a paper representing the greatest contribution to the advancement and use of welding for the year 1944.

E. W. Spring (A '26, M '32) engineer, electrical system, Detroit (Mich.) Edison Company, is on leave of absence from that company to serve as engineer for the Detroit Metropolitan Aviation Planning Authority. Mr. Spring is liason between the Michigan Aeronautics Authority and the firms which are conducting its regional airport survey.

F. B. Jewett (A '03, F '12) chairman of the National Defense Research Committee, who has just retired as vice-president of the American Telephone and Telegraph Company, New York, N. Y., recently was elected an honorary member of the New York Electrical Society.

Gano Dunn (A '91, F '12) president of the J. G. White Engineering Corporation, New York, N. Y., recently was made an honorary member of the American Society of Mechanical Engineers and of the New York Electrical Society.

G. W. Lawrence (A '19) president, Sangamo Company, Ltd., Leaside, Ontario, Canada, has been elected to the provisional board of directors of the lately founded Canadian Electrical Manufacturers' Association.

D. S. Young (A '28, M '36) formerly district engineer, Anaconda Wire and Cable Company, Chicago, Ill., has joined the staff of the Canada Wire and Cable Company, Ltd., Toronto, Ontario, Canada, as development engineer.

C. C. Sowards (A '40) captain in the Ordnance Department, United States Army, Milwaukee (Wis.) Ordnance Plant, has been relieved of active duty and will return to his position with the Copperweld Steel Company, Glassport, Pa.

K. G. Kempf (A '43) formerly district manager, Thomas Betts and Company, Los Angeles, Calif., has been appointed Pacific Coast manager for the company with which he has been associated since 1935.

Maurice Holland (A '23, M '30) industrial research adviser, New York, N. Y., has been appointed industrial research adviser to the Midwest Research Institute, Kansas City, Mo.

L. E. Messinger (A '30) president, Line Materials, Ltd., Toronto, Ontario, Canada, has been elected treasurer of the new Canadian Electrical Manufacturers' Association.

C. P. Christensen (A '14) formerly engineer in charge of installation of electric units, Grand Coulee Dam, Wash., recently was made director of power at Boulder Dam, Nev.

Sir Standen L. Pearce (A '08, F '12) engineer-in-chief, London (England) Power Company, Ltd., has been elected to honorary membership in the American Society of Mechanical Engineers.

J. R. Kearney, Jr. (M '25) chairman of the board, James R. Kearney Corporation, St. Louis, Mo., has been elected president of the National Industrial Advertisers Association.

C. L. Collens, 2nd (A '07, M '40) formerly president of the Reliance Electric and Engineering Company, Cleveland, Ohio, has become chairman of the board for the company.

J. B. Clapp (A '24, M '36) formerly sales engineer, James R. Kearney Corporation, New York, N. Y., now is associated with Thomas and Betts Company, Elizabeth, N. J.

OBITUARY • • • •

Alfred Cookman Marshall (A '14, F '29) director, consultant, and chairman of the operating council of The Detroit (Mich.) Edison Company, died February 9, 1945. Mr. Marshall, who was born in Middletown, Ohio, September 26, 1872, was graduated from the University of Michigan in 1893 with the degree of bachelor of science in electrical engineering. He also held the honorary degrees of master of science from the University of Michigan (1932) and of doctor of arts from Wayne University (1934). Mr. Marshall was employed first by the Public Lighting Commission of the City of Detroit from 1894 until 1899 when he became chief engineer of the Rapid Railway System. He left the latter position in 1904 to become engineer on construction work for The Detroit Edison Company and in 1905 was appointed general manager of the Port Huron Light and Power Company. In 1911 he was elected assistant to the president of the Eastern Michigan Edison Company and in 1912 a vice-president of the Detroit Edison Company. In addition he was named general manager in 1921 and president and general manager in 1940. He retired as president in 1944. He had been a director of the company since 1920. Active in civic life, Mr. Marshall was a member of the Board of Water Commissioners of the City of Detroit from 1925 to 1926 and served as liquidating trustee of the Detroit Trust Company from 1933 to 1940. He was elected a director of the Federal Reserve Bank of Chicago in 1935, and also had served as president and trustee of the Detroit Bureau of Governmental Research, vice-president of the Detroit Industrial Safety Council, member of the Advisory Board of the Salvation Army, member of the advisory council of the Detroit Citizens League, member of the board of directors of the Detroit Community Fund and the Committee on City Audit, president and permanent trustee of the Rackham Engineering Foundation, and trustee of the Wayne University Foundation and of Harper Hospital. He was a member of the American Society of Civil Engineers, the Engineering Society of Detroit, the United States Chamber of Commerce, and the executive committee of the Association of Edison Illuminating Companies.

John Dudley Ball (A '11, M '13, F '20) professor of physics, Mount Mary College, Milwaukee, Wis., died February 10, 1945. Doctor Ball, who was born December 8, 1882, in Seneca, Ill., was graduated from the University of Illinois with the degree of bachelor of science in 1907 and received the degree of electrical engineer in 1915. From Marquette University he received the degree of doctor of philosophy in 1928. He entered the test department of the General Electric Company, Schenectady, N. Y., in 1907 and later was transferred to the standardizing laboratory and the consulting engineering department. During this time he was associated with C. P. Steinmetz in the development of silicon steels. In 1917 he joined the Milwaukee School of Engineering as professor of electrical engineering and served as dean from 1918 to 1920 and educational director from 1926 to 1934. Since 1933 he had been professor of physics and business administration at Mount Mary College. For his work in electromagnetism he was awarded the Edward Longstreth Medal of the Franklin Institute for 1916, and he was the author of many technical papers in both English and German. He once was conductor of the General Electric Symphony Orchestra. Doctor Ball was a many-sided participant in community life and served as president of the first Mayor's Advisory Council and of the Milwaukee Civic Commission and as member of the Engineers' Examining Board of the City of Milwaukee. He was a past president of the Engineers' Society of Milwaukee, past chairman of the AIEE Milwaukee Section, and a fellow of the American Association for the Advancement of Science.

Raymond Sterling Kelsch (A '02, M '03, F '12) retired consulting engineer, and former AIEE vice-president (1918–19), died February 4, 1945, in Montreal, Quebec, Canada. He was born May 19, 1862, in Chicago, Ill., and studied at the Armour Institute. He was repairman, operator, assistant manager, manager, and division superintendent for the American District Telegraph and Telephone Company, later the Chicago Telephone Company, from 1877 to 1883. Thereafter he was station superintendent and general superintendent for the Chicago Arc Light and Power Company and, when in 1893 the company was absorbed by the Chicago Edison Company, he was appointed superintendent of high-voltage systems. In 1897 he resigned to become general superintendent and engineer of the Lachine Rapids Hydraulic and Land Company, Ltd., Montreal. After 1903 Mr. Kelsch practiced privately as a consulting engineer, and as such had been retained until his death by the former Montreal Light, Heat and Power Consolidated Company. He retired in 1926. He was a commissioner of Montreal's Electrical Service Commission, a member and past president of the Canadian Electrical Association, a member of the Institution of Electrical Engineers, the Professional Engineers of the Province of Quebec, and a member and one-time councilor of the Engineering Institute of Canada. He was elected honorary chairman of the new AIEE Montreal Section in 1943.

Hugh Alexander Brown (A '16, M '26) professor of electrical engineering, University of Illinois, Urbana, died February 25, 1945. Born in Cedar Springs, Pa., June 19, 1889, Professor Brown received the degrees of bachelor of science in 1911, master of science in 1913, and electrical engineer in 1915 from the University of Illinois. After a short employment with the General Electric Company, Schenectady, N. Y., and the Illinois Traction System, Peoria, he commenced his teaching career as instructor at the University of Arkansas, Fayetteville, in 1916. He was on the staff of the United States School of Military Aeronautics in 1917, Ottawa (Kans.) University in 1919, and of Pennsylvania State College in 1920. He joined the faculty of the University of Illinois in 1921. Professor Brown instituted the courses in radio engineering at the University and was the inventer of an alkali-vapor detector tube and the discoverer of a new method of testing insulation. He was the author of "Radio-Frequency Electrical Measurements," a textbook, as well as other popular articles. He was a member of the Institute of Radio Engineers and the Society for the Promotion of Engineering Education.

George Kimball Manson (A '09, F '23) retired chief engineer, New England Telephone and Telegraph Company, Boston, Mass., died in Brookline, Mass., January 6, 1945. Born April 4, 1876, in East Haverhill, N. H., Mr. Manson was graduated from Phillips Exeter Academy in 1894. His entire engineering career was spent with the New England Telephone Company for which he started work as a night operator in 1891. He was appointed assistant in the office of the electrical engineer in 1898, assistant electrical engineer in 1900, assistant chief engineer in 1902, engineer in 1905, and chief engineer in 1912. Mr. Manson supervised the design and building of most of the company's central telephone offices, developed dial service, and planned the first ship-to-shore radiotelephone service in New England. He had served on the City of Boston Noise Commission, and the City of Boston Traffic Control Committee and was a past president of the city's Engineers Club. At his death he was president of the Franklin Foundation and was chief business consultant of the communications division of the War Production Board.

Harry Munson Warren (A '03) chief engineer, Glen Alden Coal Company, Scranton, Pa., died February 3, 1945. He was born November 22, 1875, in Worcester, Mass., and was graduated from Worcester Polytechnic Institute in 1896. After a brief period with the General Electric Company, Schenectady, N. Y., he entered the coal mining department of the Delaware Lackawanna and Western Railway Company, Scranton, and in 1921 became consulting engineer for the Glen Alden Company. He also was electrical engineer of the Key-stone Mining Company. He was a member of a commission appointed by Theodore Roosevelt to study mining in Europe. Mr. Warren was identified prominently with the development of the use of fine-size anthracite for power production purposes and the development of the multistage centrifugal pump and the electrifying of coal breakers. Mr. Warren was a member of the United States Fuel Administration during World War I and of the American Railway Engineering Association. He was a charter member and past president of the Engineering Society of Northeastern Pennsylvania.

John Carleton Albert (A '10, M '34) assistant electrical engineer, Department of Water and Power, City of Los Angeles, Calif., died January 16, 1945. Mr. Albert was born in Lima, Ohio, June 11, 1883, and entered electrical work as an apprentice in various contracting shops about 1903. He was employed as a tester by the Jeffrey Manufacturing Company, Columbus, Ohio, and as an inspector by the Pacific Electric Railway Company, Los Angeles, before 1910. In 1910 he commenced an association as chief electrician with the Minas del Tajo, Rosario, Sinaloa, Mexico, which lasted irregularly until 1916. During this period he also was employed in the testing laboratory of the Pacific Light and Power Company, Los Angeles. In 1917 he became assistant electrical engineer in charge of the testing laboratories of the Los Angeles Bureau of Power and Light which was later absorbed by the Department of Water and Power. He retired in 1944.

MEMBERSHIP • • •

Recommended for Transfer

The board of examiners, at its meeting on March 15, 1945, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Calvert, J. F., chairman, dept. of elec. engg., Northwestern Technological Institute, Evanston, Ill.
Gonseth, J. E., asst. gen. mgr., Automatic Electric Co.; vice-pres., Associated Elec. Labs., Inc., Chicago, Ill.
Graybill, K. W., pres., Automatic Elec. Labs., Inc., Chicago, Ill.
Johnson, J. Hugo, prof. of elec. engg., University of Idaho, Moscow, Idaho
Lewis, W. A., consultant in elec. engg., Armour Research Foundation, Chicago, Ill.
Nystrom, C. W., general outside plant engr., Southwestern Bell Tel. Co., St. Louis, Mo.
Ricker, C. W., prof. and head, School of Elec. Engg., Tulane University, New Orleans, La.

7 to grade of Fellow

To Grade of Member

Blaese, A. C., Manufacturers Agent, Valparaiso, Ind.
Bottanari, S. A., elec. design engr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Brown, D. L., testing engr., Portland General Elec. Co., Portland, Oreg.
Brown, F. H., sales engr., Copperweld Steel Co., New York, N. Y.
Cleaver, J. J., mgr., Public Utilities Commission, Almonte, Ont., Canada.
deBonneval, H. A., chief elec. engr., George G. Sharp, New Orleans, La.
Devine, L. V., elec. engr., Moloney Elec. Co., St. Louis, Mo.
Everhart, J. G., asst. to chief transformer engr., Line Material Co., Zanesville, Ohio.
Ewart, W. L., supt. of utilities, Lago Oil & Transport Co. Ltd., Aruba, Curacao, West Indies
Gagnier, C. E., elec. design engr., North American Aviation, Inc., Inglewood, Calif.
Gould, E. H., Lieut. Comdr., USNR, Mare Island Navy Yard, Calif.
Haun, B. O., engr., Emerson Electric Mfg. Co., St. Louis, Mo.
Heffernan, J. A., elec. engg. asst., Public Service Elec. & Gas Co., Newark, N. J.
Johnson, J. S., elec. engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Lapsley, R. P., Lieut. Colonel, Chief of Electrical Section, U. S. Engineers, Atlanta, Ga.
Leake, W. S., sales engr., General Elec. Co., New Orleans, La.
MacEwell, M., engg. and service supervisor, Westinghouse Elec. & Mfg. Co., Portland, Oreg.
Madison, E. A., vice-pres., The Starbuck Sprague Co., Waterbury, Conn.
Martz, C. J., chief engr., City of Huntsville Electric System, Huntsville, Ala.
McCarty, W. R., elec. engr., Wagner Elec. Corp., St. Louis, Mo.
McLeod, L. W., central station division mgr., Westinghouse Elec. & Mfg. Co., St. Louis, Mo.
Meissner, E. B., president and general mgr., St. Louis Aircraft Corp., St. Louis, Mo.
Moore, J. F., elec. engr., Dunlop Tire & Rubber Goods Co., Ltd., Toronto, Ont., Canada.
Morton, L. W., rectifier application engr., General Elec. Co., Schenectady, N. Y.
Munier, R. F., chief motor engr., Emerson Elec. Mfg. Co., St. Louis, Mo.
Nelson, H. R., asst. plant supt., Tennessee Valley Authority, Guntersville, Ala.
Peterson, A. P., president, Control Corp., Minneapolis, Minn.
Phillips, W. R., elec. engr., Moloney Elec. Co., St. Louis, Mo.
Rohlfsen, A. G., elec. supervisor, Johns-Mansville, Lompoc, Calif.
Rothfus, E. A., design engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Schoetker, R. W., substation engr., Union Elec. Co. of Missouri, St. Louis, Mo.
Seybt, H. B., sales engr., General Elec. Co., St. Louis, Mo.
Sidenfaden, O. L., elec. engr., Dept. of Water & Power, Los Angeles, Calif.
Somerville, J. M., chief engr., Canadian Porcelain Co. Ltd., Hamilton, Ont., Canada.
Stanwix-Hay, Walter, commercial engr., General Elec. Co., Bridgeport, Conn.
Steensen, A. P., engr., The Foxboro Co., Foxboro, Mass.
Stock, H. F., asst. elec. engr., Pratt & Whitney Aircraft Corp. of Missouri, Kansas City, Mo.
Stodola, E. K., engr., Camp Evans Signal Laboratory, Belmar, N. J.
Whiteley, Eric, asst. D. C. engr., Canadian General Elec. Co. Ltd., Peterborough, Ont., Canada

39 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the national secretary before May 15, 1945 or July 15, 1945, if the applicant resides outside of the United States or Canada.

To Grade of Member

Alioto, J. J., Globe-Union, Inc., Milwaukee, Wis.
Alvarado, G., Worthington Pump & Mchy. Corp., Harrison, N. J.
Anderson, D., Southern Can. Pr. Co., Ltd., Montreal, Que., Can.
Antes, L. L., Univ. of Texas, Austin, Tex.
Arkhangelsky, G. D., Pur. Com., U.S.S.R., New York, N. Y.
Arstad, L. O., Northwestern Bell Tel. Co., Des Moines, Iowa
Ayers, E. H. (Reelection), Gen. Elec. Co., Schenectady, N. Y.
Ayres, A. F. (Reelection), Calif. Elec. Pr. Co., Riverside, Calif.
Banan, H. F. (Reelection), Elec. Machinery Mfg. Co., New York, N. Y.
Bedi, B. H. S. (Reelection), Diesel Power Station, Simla, India
Bird, J. R., Bird Engg. Co., Cleveland, Ohio
Boswell, C. C., Minn. Pr. & Lt. Co., Duluth, Minn.
Briscoe, L. E. (Reelection), Ayrshire Collieries Corp., Indianapolis, Ind.
Burns, R., Whitehead Iron & Steel Co., Ltd., Newport, Wales
Cline, J. F. (Reelection), Univ. of Mich., Ann Arbor, Mich.
Colburn, A. R. (Reelection), Rural Elec. Adm., St. Louis, Mo.
Cook, E. F. I., RAF, Alresford, England
Crago, H. R., Gen. Elec. Co., Schenectady, N. Y.
Dauenhauer, C. M., Kellex Corp., Knoxville, Tenn.
Ellis, J. L. (Reelection), Lieut. Comdr., U.S.N.R., Annapolis, Md.
Fannon, J. L. (Reelection), Stone & Webster Engg. Corp., Boston, Mass.
Gallagher, J. D. (Reelection), Hartford Accid. & Indem. Co., Chicago, Ill.
Gardner, E. R. (Reelection), Gen. Elec. Co., W. Lynn, Mass.
Hall, R. S., Jr., Captain, U. S. Army, Fort Lewis, Wash.
Harden, J. C., S. C. Elec. & Gas Co., Columbia, S. C.
Harder, A. W., Lieut. (jg), U.S.N.R., Dallas, Tex.
Harvey, D. A. (Reelection), Patent Lawyer, St. Louis, Mo.
Heston, W. C. (Reelection), "Electrical West," San Francisco, Calif.
Hugon, J., French Supply Mission, Washington, D. C.
Jones, W. S. (Reelection), National Elec. Prod. Corp., Pittsburgh, Pa.
Jordan, T. (Reelection), Amer. Smelt. & Ref. Co., Garfield, Utah.
Kaspar, A. A. (Reelection), Laclede Pr. & Lt. Co., St. Louis, Mo.
Kirillov, E. V., Pur. Com., U.S.S.R., New York, N. Y.
Kurtz, J. (Reelection), International Smelting & Ref. Co., Tooele, Utah
Lang, C. M., Tenn. Val. Auth., Knoxville, Tenn.
Langelier, G., J. A. Jones Const. Co., Brunswick, Ga.
Lexa, G. J. (Reelection), Cutler-Hammer, Inc., Milwaukee, Wis.
Lix-Klett, E. (Reelection), E. Lix-Klett & Co., Buenos Aires, Arg., S. A.
Martinez, J. B., Reynolds Elec. & Engg. Co., Inc., El Paso, Tex.
Miller, E. P., S. C. Elec. & Gas Co., Columbia, S. C.
Morris, R. V. (Reelection), Northern Ind. Pub. Serv. Co., Gary, Ind.
Murray, J. A., Douglas Aircraft Co., Inc., Santa Monica, Calif.
Negley, S. R., Reading Co., Philadelphia, Pa.
Nicholson, J. R. (Reelection), Gen. Elec. Co., New York, N. Y.
Onder, K., Com. Equip. Corp., Pasadena, Calif.
Palmquist, J. F., Don Lee Broadcast., Inc., Hollywood, Calif.
Patton, L. E., Cons. Engr., San Francisco, Calif.
Pignolet, L. W. (Reelection), Weston Elec. Inst. Corp., Newark, N. J.
Pullinger, W. W., Lieut. R.C.N.V.R., Ottawa, Ont., Can.
Roberts, F. W., Crompton Parkinson, Ltd., Chelmsford, England
Schwartz, N. J., Heinemann Circuit Breaker Co., Trenton, N. J.
Siegel, D. T., Obmite Mfg. Co., Chicago, Ill.
Starcke, M., Lower Colo. River Auth., Austin, Tex.
Stayner, C. M. (Reelection), Union Pacific R.R., Salt Lake City, Utah
Stephens, W. P., National Sup. Co., Springfield, Ohio
Warren, C. A. (Reelection), Portland Gen. Elec. Co., Portland, Oreg.
Waterman, A. L., Dartmouth Col., Hanover, N. H.
Williams, A. L. (Reelection), Great Lakes Carbon Corp., Niagara Falls, N. Y.

58 to grade of Member

To Grade of Associate

United States and Canada

1. North Eastern

Azua, R. V., Jr., Intl. Gen. Elec. Co., Schenectady, N. Y.
Berg, L. D. T., Gen. Elec. Co., Schenectady, N. Y.
Chabal, V. W., Gen. Elec. Co., Syracuse, N. Y.
Chapman, C. H. (Reelection), Gen. Elec. Co., Schenectady, N. Y.
Cooper, J. D., Stromberg-Carlson Co., Rochester, N. Y.
Cummings, J. D., Gen. Elec. Co., Schenectady, N. Y.
Davis, M. F., Gen. Elec. Co., Schenectady, N. Y.
del Palacio, J., Gen. Elec. Co., Schenectady, N. Y.
Demartini, R. J., Gen. Elec. Co., Schenectady, N. Y.
D'Entremont, F. R., Gen. Elec. Co., Lynn, Mass.
Dixon, E. O., Eastman Kodak Co., Rochester, N. Y.
Duryea, J. B., Gen. Elec. Co., Schenectady, N. Y.
Edgerly, A. H., A. S. Mancib Co., West Somerville, Mass.
Fairley, R. K., Gen. Elec. Co., Schenectady, N. Y.
Fink, W. A., Stromberg-Carlson Co., Rochester, N. Y.
Franck, R. E., Gen. Elec. Co., Lynn, Mass.
Friedman, H. M., Gen. Elec. Co., Schenectady, N. Y.
Gillespie, H., Gen. Elec. Co., Schenectady, N. Y.
Glassman, A., Gen. Elec. Co., Schenectady, N. Y.
Hausler, G. M., Gen. Elec. Co., Schenectady, N. Y.
Holt, J. W., Jr., Gen. Elec. Co., Schenectady, N. Y.
Horton, M., Gen. Elec. Co., Schenectady, N. Y.
Hutchinson, H. H., Gen. Elec. Co., Schenectady, N. Y.
Hyman, B., Sylvania Elec. Prod., Inc., Salem, Mass.
Juengst, J. H., Eastman Kodak Co., Rochester, N. Y.
Kelley, F. W., Jr., Gen. Elec. Co., Schenectady, N. Y.
Kelly, L. J., Gen. Elec. Co., Lynn, Mass.
Kemnitz, W. N., Gen. Elec. Co., Schenectady, N. Y.
Knapp, G. W., Gen. Elec. Co., Schenectady, N. Y.
Kranz, H. P., Narragansett Elec. Co., Providence, R. I.
Larkin, T. E., Gen. Elec. Co., Schenectady, N. Y.
Lemmo, R. J., Maguire Ind., Greenwich, Conn.
Lyon, R. P., Stromberg-Carlson Co., Rochester, N. Y.
Mander, A. E. Jr., Gen. Elec. Co., Schenectady, N. Y.
Midgley, P. L., Gen. Elec. Co., Schenectady, N. Y.
Moore, R. B., Gen. Elec. Co., Schenectady, N. Y.
Moshy, A. M., Intl. Gen. Elec. Co., Schenectady, N. Y.
Petraske, K. A., Gen. Elec. Co., Schenectady, N. Y.
Plaisted, G. E. (Reelection), Gen. Elec. Co., Schenectady, N. Y.
Plonsky, A. W., Mass. Inst. of Tech., Cambridge, Mass.
Popper, H., Gen. Elec. Co., Schenectady, N. Y.
Raney, E. A., Gen. Elec. Co., Pittsfield, Mass.
Reagan, L. H., Stromberg-Carlson Co., Rochester, N. Y.
Reehl, G. H., Gen. Elec. Co., Schenectady, N. Y.
Reese, D. R., Gen. Elec. Co., Schenectady, N. Y.
Reeves, F. E., Elec. Apparatus Co., Boston, Mass.
Ridgley, C. H., Gen. Elec. Co., Lynn, Mass.
Ridley, W. H., Jr., Stromberg-Carlson Co., Rochester, N. Y.
Rockwell, R. L., Gen. Elec. Co., Schenectady, N. Y.
Sachs, S. I., Maguire Ind., Inc., Greenwich, Conn.
Sammons, W. L., Gen. Elec. Co., Schenectady, N. Y.
Schwartz, S., Gen. Elec. Co., Schenectady, N. Y.
Smith, D. R., Sr., Gen. Elec. Co., Schenectady, N. Y.
Smoot, E. P., Gen. Elec. Co., Schenectady, N. Y.
Snady, H. W., Intl. Gen. Elec. Co., Schenectady, N. Y.
Sowell, P. B., Gen. Elec. Co., Schenectady, N. Y.
Swindells, N. M., Blackstone Val. Gas & Elec. Co. Pawtucket, R. I.
Thomas, W. T., Gen. Elec. Co., Schenectady, N. Y.
Tiner, I. M., Mass. Inst. of Tech., Cambridge, Mass.
Turrentine, F. R., Gen. Elec. Co., Schenectady, N. Y.

Wheeling, R. F., Eastman Kodak Co., Rochester, N. Y.
Whittlesey, S. I., Gen. Elec. Co., Schenectady, N. Y.
Williams, J. E., Gen. Elec. Co., Schenectady, N. Y.
Williamson, S. H., Gen. Elec. Co., Schenectady, N. Y.
Wilson, G. A., Jr., Mass. Inst. of Tech., Cambridge, Mass.
Yasi, J. W., Gen. Elec. Co., Lynn, Mass.
Yeaton, A. G., Sylvania Elec. Prod., Inc., Dover, N. H.
Zachary, R. A., Jr., Gen. Elec. Co., Schenectady, N. Y.

2. MIDDLE EASTERN

Allen, C. E., Westinghouse Elec. & Mfg. Co., Baltimore, Md.
Baranetski, S., Westinghouse Elec. & Mfg. Co., Pittsburgh, Pa.
Beck, R. E., Jr., U. S. Army, Ohio State Univ., Columbus, Ohio
Benowitz, S., Westinghouse Elec. & Mfg. Co., Cleveland, Ohio
Block, H. S., Nat. Bur. of Standards, Washington, D. C.
Bromley, R. W., Bureau of Ships, Washington, D. C.
Brown, F. D., Westinghouse Elec. & Mfg. Co., Baltimore, Md.
Brumfield, F. E., Ohio Bell Tel. Co., Cleveland, Ohio
Bulley, J. E., Gen. Elec. Co., Erie, Pa.
Cockrum, C. A., Lear, Inc., Piqua, Ohio
Corcoran, C. S., Jr., N.A.C.A., Cleveland, Ohio
Corporon R. P., Radio Corp. of America, Camden, N.J.
Davis, D. H., Henry J. Kunzig, Baltimore, Md.
Di Meglio, M., Philco Corp., Philadelphia, Pa.
Dunn, M. M., Lear, Inc., Piqua, Ohio
Epstein, A. S., Radio Corp. of America, Camden, N. J.
Erisman, R., Jr., Lear, Inc., Piqua, Ohio
Foulks, E. C., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Galeski, R. J., N.A.C.A., Cleveland, Ohio
Gilbert, D. K., Leland Elec. Co., Dayton, Ohio
Gilleo, M. A., U. S. Navy Dept., Washington, D. C.
Hampton, W. C., Lieut., M.B.E.R.N., Washington, D. C.
Henne, W. P., Koppers Co., Inc., Monaca, Pa.
Hess, R. D., Lear, Inc., Piqua, Ohio
Hunt, R. A., Cleveland, Elec. Illum. Co., Cleveland, Ohio
Inskeep, M. J., Lear, Inc., Piqua, Ohio
Ireland, R. A., Jr., N.A.C.A., Cleveland, Ohio
Jachym, T. M., Lieut., AAF, Wright Field, Dayton, Ohio
Jeakins, J. W., Gen. Elec. Co., Philadelphia, Pa.
Johnson, B. W., Oliver Iron & Steel Corp., Pittsburgh, Pa.
Koenig, J. F., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Lange, A. Q., James G. Biddle Co., Philadelphia, Pa.
Long, W. A., Intl., Min. & Chem. Corp., Rossford, Ohio
Lynch, E. F., Diamond Alkali Co., Painesville, Ohio
MacArthur, A., Jr., P-V Engg. Forum, Sharon Hill, Pa.
Martindale, H. C., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
McCown, W. E., Radio Corp. of America, Camden, N. J.
McCullough, S., N.A.C.A., Cleveland, Ohio
Michael, P. H., U. S. Navy, Mansfield, Ohio
Mikell, W. G., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Myers, C. R., III, Radio Corp. of America, Camden, N. J.
Newberry, D. A., Ensign, U.S.N.R., Columbus, Ohio
Nipper, E. E., Gen. Elec. Co., Erie, Pa.
Odishaw, H., Westinghouse Elec. & Mfg. Co., Pittsburgh, Pa.
Poffenberger, C. O., Gen. Elec. Co., Baltimore, Md.
Rademacher, L. B., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Royer, C. E., Cleveland Elec. Illum. Co., Cleveland, Ohio
Silverio, V. J., Gen. Elec. Co., Philadelphia, Pa.
Stark, D. E., Stupakoff Cer. & Mfg. Co., Latrobe, Pa.
Stegman, W. L., U.S.C.G., Baltimore, Md.
Stitelman, J., U. S. Civil Serv. Comm., Washington, D. C.
Vogeley, C. E., Jr., Westinghouse Res. Lab., East Pittsburgh, Pa.
Ward, S. A., U. S. Naval Res. Lab., Washington, D. C.
Wells, M. M., Bird Engg. Co., Cleveland, Ohio
Woolley, J., Antioch Foundry, Yellow Springs, Ohio

3. NEW YORK CITY

Astrain, S., Corp. de Fom. de la Prod. of Chile, New York, N. Y.
Baker, G. H., Bell Tel. Labs., Inc., New York, N. Y.
Blackburne, T. F., Electronic Labs., Inc., New York, N. Y.
Bourquin, J. L., Jr., Sperry Gyroscope Co., Garden City, N. Y.
Casey, E. J., National Union Radio Corp., Newark, N. J.
Clinkscales, E. L., Western Union Tel. Co., New York, N. Y.
Coughlin, J. J., U. S. Navy Yard, Brooklyn, N. Y.
DeVebre, E. W., Westinghouse Elec. & Mfg. Co., New York, N. Y.
Devers, W. J., Allis-Chalmers Mfg. Co., New York, N. Y.
Eder, W. L., Cons. Shipbldg. Corp., New York, N. Y.
Escoffery, A. L., Westinghouse Elec. Intl. Co., New York, N. Y.
Fry, M., W. L. Maxson Corp., New York, N. Y.
Fung, K. W., Bell Tel. Labs., Inc., New York, N. Y.
Gambuti, F. F., Wright Aero Corp., Woodridge, N. J.
Hawkins, J. N. A., Sylvania Elec. Prod., Inc., New York, N. Y.
Kern, R. E., Curtiss-Wright Corp., Caldwell, N. J.
Klay, A. M., Western Elec. Co., New York, N. Y.
Knowles, B. R., U.S.A.A.F., New York, N. Y.
Lawton, B. E., Westinghouse Elec. & Mfg. Co., Bloomfield, N. J.
Littell, J. G., Natl. Union Radio Corp., Newark, N. J.
Mapp, F. J., Midshipman, U.S.N.R., Brooklyn, N. Y.
Mayer, C. R., Sonotone Corp., Elmsford, N. Y.
Mazzitelli, G. A., J. A. Tuck, Consultant, New York, N. Y.
Menzel, H. R., Sperry Gyro. Co., Inc., Garden City, N. Y.
Mullally, J. W., Anacaonda Wire & Cable Co., New York, N. Y.
Nittoli, V. A., U. S. Army, Flushing, N. Y.
Orowski, S. H., Pan American Airways, Jackson Heights, N. Y.
Petruska, J. M., Wright Aero. Corp., Woodridge, N. J.
Quirke, J. F., Westinghouse Elec. Elev. Co., Jersey City, N. J.
Rapetti, E. J., Arma Corp., Brooklyn, N. Y.
Rivera, E., Kellex Corp., New York, N. Y.
Stark, O. C., Square D Co., New York, N. Y.
Storch, H., Fed. Tel. & Radio Labs., New York, N. Y.
Stroup, L. G., Bendix Avia. Corp., Brooklyn, N. Y.
Swanson, E. H., Radio Engg. Labs., Inc., Long Island City, N. Y.
Tyne (Mrs.) G. H., Allied Control Co., Inc., New York, N. Y.
Wellen, S. D., Empire Elec. Brake Co., Newark, N. J.
White, J. H. F., Westchester Lighting Co., Pleasantville, N. Y.
White, N. N., Western Elec. Co., Kearny, N. J.
Zywotow, S. J., Western Elec. Co., Jersey City, N. J.

4. SOUTHERN

Berg, A. A., Tenn. Eastman Corp., Knoxville, Tenn.
Brenn, E. A., Republic Min. & Mfg. Co., Bauxite, Ark.
Brock, T. R., Gen. Elec. Co., Knoxville, Tenn.
Brown, H. B., Jr., Carbide & Carbon Chem. Corp., Oak Ridge, Tenn.
Campbell, C. E., Tenn. Eastman Corp., Oak Ridge, Tenn.
Colon, C. M., Southwestern Gas & Elec. Co., Shreveport, La.
Dukes, R. C., Lieut., U.S.N.R., Charleston, S. C.
Fagan, E. M., Lt. Col., U.S.A.A.F., Little Rock, Ark.
Harvey, G. L., Carbon & Carbide Chem. Corp., Oak Ridge, Tenn.
Lockwood, J. A., Tenn. Eastman Corp., Oak Ridge, Tenn.
McAllister, P. F., N.A.C.A., Langley Field, Va.
Murray, J. G., N.A.C.A., Langley Field, Va.
Nuchols, J. N., Carbide & Carbon Chem. Corp., Oak Ridge, Tenn.
Penuel, S. S., S-2/c, U. S. Navy, Birmingham, Ala.
Rutherford, H. L., Carbide & Carbon Chem. Corp., Oak Ridge, Tenn.
Scott, R. S., Watson-Flagg Engg. Co., Oak Ridge, Tenn.
Seldon, M. R., N.A.C.A., Langley Field, Va.
Smith, G. C., Jr., Carbide & Carbon Chem. Corp., Oak Ridge, Tenn.
Steele, G. R., Gen. Elec. Co., Norfolk, Va.
Sullivan, D. F., Tenn. Eastman Corp., Oak Ridge, Tenn.
Tarlton, S. L., Rayonier, Inc., Fernandina, Fla.
Thagard, G. S., Gen. Elec. Co., Knoxville, Tenn.
Willoch, H. (Reelection), Tenn. Val. Auth., Chattanooga, Tenn.

5. GREAT LAKES

Baerwald, H. J., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Beter, R. H., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bosse, P. J., Northern Ind. Pub. Serv. Co., Gary, Ind.
Brown, W. E., Cutler-Hammer, Inc., Milwaukee, Wis.
Buhler, C. G., A-C Spark Plug Div., Flint, Mich.
Burleigh, S. A., Vickers, Inc., Detroit, Mich.
Christensen, R. T., Zenith Radio Corp., Chicago, Ill.
Comings, W. S., Jr., Minneapolis-Honeywell Reg. Co., Minneapolis, Minn.
Cory, H. W., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Danner, R. V., Admiral Corp., Chicago, Ill.
Doescher, E. B., Northern States Pr. Co., Minneapolis, Minn.
Ebeltoft, W. H., Minneapolis-Honeywell Reg. Co., Minneapolis, Minn.
Johnson, J. F., Corn Prod. Refg. Co., Pekin, Ill.
Jones, R. J., Globe-Union, Inc., Milwaukee, Wis.
Joscelyn, W. J., Sundstrand Mach. Tool Co., Rockford, Ill.
Kelly, J. M., Jr., Consumers Pr. Co., Jackson, Mich.
Krueger, J., Univ. of Minn., St. Paul, Minn.
Lamons, R. P., Western Elec. Co., Chicago, Ill.
Lorenz, A. D., Western Elec. Co., Chicago, Ill.
Miller, J. W., National Elec. Coil Co., Crete, Ill.
Niksch, E. E., Allis-Chalmers Mfg. Co., West Allis, Wis.
Peeples, R. M., Allis-Chalmers Co., Milwaukee, Wis.
Reddricks, J. T., U.S.A.A.F. Depot, South Bend, Ind.
Shaltis, R. J., Western Elec. Co., Chicago, Ill.
Shipman, J. S., Gen. Elec. Co., Fort Wayne, Ind.
Stange, H., Jr., U. S. Rubber Co., Mishawaka, Ind.
Sturmack, L., Janette Mfg. Co., Chicago, Ill.
Voss, H. J., Moody Bible Inst., Elmhurst, Ill.
Walden, J. M., Black Hills Broadcasting Co., Rapid City, S. Dak.
Witchey, A. L., Radio Corp. of America, Indianapolis, Ind.

6. NORTH CENTRAL

Dodd, N. M., Kaiser Ind., Inc., Denver, Colo.
Lindseth, E. V., U. S. Bur. of Rec., Denver, Colo.
Utlaut, W. F., U.S.N.R., 532 Park St., Sterling, Colo.

7. SOUTH WEST

Chandler, G. M., Lower Colo. River Auth., Austin, Tex.
Cobb, J. R., Rural Elec. Adm., St. Louis, Mo.
Cochell, L. A., U. S. Engineers, Houston, Tex.
Collins, E. M., Lieut., U. S. Army, Camp Crowder, Mo.
Conner, J. O., Southwestern Bell Tel. Co., Lawton, Okla.
Ellison, J. R., Okla. Gas & Elec. Co., Oklahoma City, Okla.
Francis, J. M., New Braunfels Util., New Braunfels, Tex.
Gillespie, K. T., Okla. Elec. Sup. Co., Oklahoma City, Okla.
Gordon, C. A., Southwestern Bell Tel. Co., Houston, Tex.
Heap, W. O., Schlumberger Well Sur. Corp., Houston, Tex.
Pickens, H. L., Allis-Chalmers Mfg. Co., Oklahoma City, Okla.
Redmond, W. B., U. S. Engineer, Galveston, Tex.
Robb, D. D., Univ. of Kans., Lawrence, Kans.
Shaad, D. E., Black & Veatch, Kansas City, Mo.
Simon, P. G., Gulf States Util. Co., Beaumont, Tex.
Waldner, M., McQuay-Norris Co., St. Louis, Mo.
White, A. W., A. W. White Elec. Motor & Machy. Co., Oklahoma City, Okla.

8. PACIFIC

Blankmann, W. L., Civil Aero. Adm., Redwood City, Calif.
Brewer, W. B., Lockheed Aircraft Corp., Burbank, Calif.
Brownfield, R. E., Bur. of Pr. & Lt., Los Angeles, Calif.
Buck, C. M., Pac. Gas & Elec. Co., San Francisco, Calif.
Clayton, G. H., Lieut., U.S.N.R., Sunset Beach, Calif.
Hall, E. S., S-1/c, U. S. Navy, San Gabriel, Calif.
Holcombe, G. B., Matson Navig. Co., San Francisco, Calif.
Jeffords, R. D., Calif. Shipbldg. Corp., Wilmington, Calif.
Lovell, A. J., Sacramento Mun. Util. Dist., Sacramento, Calif.
McLaughlin, E. F., Permanente Metals Corp., Richmond, Calif.
Morris, C., Earl S. Condon Co., Los Angeles, Calif.
Nelson, A., Dept. of Water & Power, Los Angeles, Calif.
Sather, K. M., Pac. Gas & Elec. Co., San Francisco, Calif.
Schoonover, W. L., Douglas Aircraft Co., Long Beach, Calif.
Silvey, H. R., Dept. of Water Power, Los Angeles, Calif.
Sklensky, F., Douglas Aircraft Co., Inc., Santa Monica, Calif.
Smith, H. F., Cons., Vultee Aircraft Corp., San Diego, Calif.
White, M. J., Pac. Elec. Mfg. Corp., San Francisco, Calif.
Williams, H. M., City of L. A., Los Angeles, Calif.

9. NORTH WEST

Bruckner, C. G., Mont. Pr. Co., Bozeman, Mont.
Calderwood, D. S., Kaiser Co., Inc., Portland, Oreg.
Eastman, C. W., Boeing Aircraft Co., Seattle, Wash.
Elliott, D. S., Ensign, U.S.N.R., Brewster, Wash.
Griffin, B. L., Oreg. State Col., Corvallis, Oreg.
Johnson, J. H., 2323 W. Liberty Ave., Spokane 12, Wash.
Matney, T. L., Tech. Engineers Union, Local #79, Portland, Oreg.
Rogers, E. P., Bonneville Pr. Adm., Vancouver, Wash.
Smith, N. D., Naval Air Bases, Seattle, Wash.
Thurber, D. C., Goggan's & Pennie, Great Falls, Mont.
Winsor, G. C., Puget Sound Navy Yard, Bremerton, Wash.
Young, K. J., Boeing Aircraft Co., Seattle, Wash.

10. CANADA

Beaton, S. J., Can. Gen. Elec. Co., Ltd., Peterboro, Ont., Can.
Cleminson, J. A. C. C., Victory Aircraft, Ltd., Malton, Ont., Can.
Coleman, A. B. M., Lloyds Reg. of Shipping, Vancouver, B. C., Can.
Collins, T., B. C. Elec. Ry. Co., Ltd., Vancouver, B. C., Can.
Conning, A. R., Goodyear Tire & Rubber Co., New Toronto, Ont., Can.
Elsworth, P. J., John Inglis Co., Toronto, Ont., Can.
Helliwell, R. A., Stanford University, Calif.
Jackson, R. R., Can. Gen. Elec. Co., Peterboro, Ont., Can.
Julson, O. M., Can. Gen. Elec. Co., Peterboro, Ont., Can.
Kehoe, V. P., DeHavilland Aircraft Co. Ltd. of Can., Toronto, Ont., Can.
Madryga, A., Can. Gen. Elec. Co., Ltd., Peterboro, Ont., Can.
McDiarmaid, R. B., Dept. of Transport, Dom. Govt., Edmonton, Alta., Can.
Nosworthy, F. M., Bell Tel. Co. of Can., Montreal, Que., Can.
Orlando, E. E., Can. Westinghouse Co., Ltd., Montreal, Que., Can.
Overend, A. V., Can. Marconi Co., Ltd., Mount Royal, Que., Can.
Rappel, H. T., Can. Gen. Elec. Co., Ltd., Peterboro, Ont., Can.
Rome, A. H., 5891 Alma Road, Vancouver, B. C., Can.
Stanger, E. A. (Reelection), Southern Can. Pr. Co., Ltd., Montreal, Que., Can.

Elsewhere

Amin, N. B., Jyoti, Ltd., Baroda, India
Banerjee, M. N., Hindustan Aircraft, Ltd., Bangalore, India
Fuller, F. H., H. J. Fuller & Sons, Ltd., Leeds, England
Greaves, H. A., Demerara Bauxite Co., Mackenzie City, British Guiana, S. A.
Myers, L., Guest Keen Williams, Ltd., Howrah, India
Rusterholz, H. C., Cerro-de-Pasco Copper Corp., La Oroya, Peru, S. A.
Sanders, J. C. M., Crompton-Parkinson, Ltd., Chelmsford, England
Taylor, R. L., Crompton-Parkinson, Ltd., Chelmsford, England
Torruella Soto, J. A., P. R. Water Res. Auth., Santurce, P. R.

Total to grade of Associate
United States and Canada, 285
Elsewhere, 9

OF CURRENT INTEREST

Bureau of Standards Extends Broadcast Service

The National Bureau of Standards broadcast service, which comprises the broadcasting of standard frequencies and standard time intervals from the Bureau's radio station WWV near Washington, D. C., has been slightly extended by broadcasting 15 megacycles at night as well as in the daytime.

The service is continuous at all times from ten-kilowatt radio transmitters, except on 2,500 kilocycles per second where one kilowatt is used, and includes, in addition to the frequency and time standards, standard audio frequencies, and standard musical pitch, 440 cycles per second, corresponding to A above middle C. Any desired frequency may be measured in terms of the standard frequencies with the aid of harmonics and beats, with one or more auxiliary oscillators.

The radio frequencies utilized by the National Bureau of Standards are 2.5 megacycles per second, broadcast from 7:00 p.m. to 9:00 a.m., Eastern War Time; and 5, 10, and 15 megacycles per second, broadcast continuously day and night. Moreover, there is, on all carrier frequencies, a pulse of 0.005-second duration which occurs at intervals of precisely one second. The pulse consists of five cycles, each of 0.001-second duration, and is heard as a faint tick when listening to the broadcast. This provides a standard time interval for purposes of physical measurements as well as an accurate time signal. The audio frequencies are interrupted precisely on the hour and each five minutes thereafter with a one-minute interval for station announcements.

WAR PROGRAM • •

Signal Corps Has Wire-Laying Method for All Terrains

A new method of laying communication wire based on a specially designed coil and dispenser enables the Signal Corps to lay its combat wires by airplane, by ground vehicles, or by bazookas and rifle grenades without the use of reels.

The dispenser is about one foot in diameter, one-half foot in length, weighs approximately 25 pounds, and contains about 3,300 feet of assault wire. Communication may be maintained during the laying process, regardless of the mode of transportation employed. Two or more dispensers may be connected in tandem when it is necessary to lay more than one coil of wire without stopping to make a splice.

A container, which has a capacity of eight wire dispensers, has been designed for use by the Army Air Forces so that airplanes can lay a continuous five-mile circuit. Two containers can be mounted on an airplane, one under each wing, to balance the airplane and to lay two circuits at once.

The method has demonstrated its versatility under test with rifle grenades, bazookas, man pack, various ground and amphibious vehicles, and a liason-type airplane which paid out wire at speeds as high as 110 miles an hour. Its adaptability is expected to reduce the requirements for wire-laying equipment and eliminate maintenance of certain mechanical parts.

An important advantage of the new method, which some experts predict may revolutionize the installation of wire communications, is the fact that wire can be laid manually by mountain, ski, or ground troops. Another advantage is silent operation, an important factor in many theaters. The laying of wire by airplane over mountain peaks, deep valleys, or dense forests will simplify greatly the operations of communications troops. In forests or thick jungles wire can be laid over the tops of trees or inaccessible undergrowth. One of the principal uses of paying out wire by bazooka or rifle grenade will be to connect advance patrols or strong points in no man's land.

Allies in Italy Centralize Power-Generation Facilities

The electric generating plants in central Italy have been brought under a central control system under the guidance and direction of the Public Works and Utilities Subcommission of the Allied Commission. This action had the support of the Italian Government and of the private concerns involved.

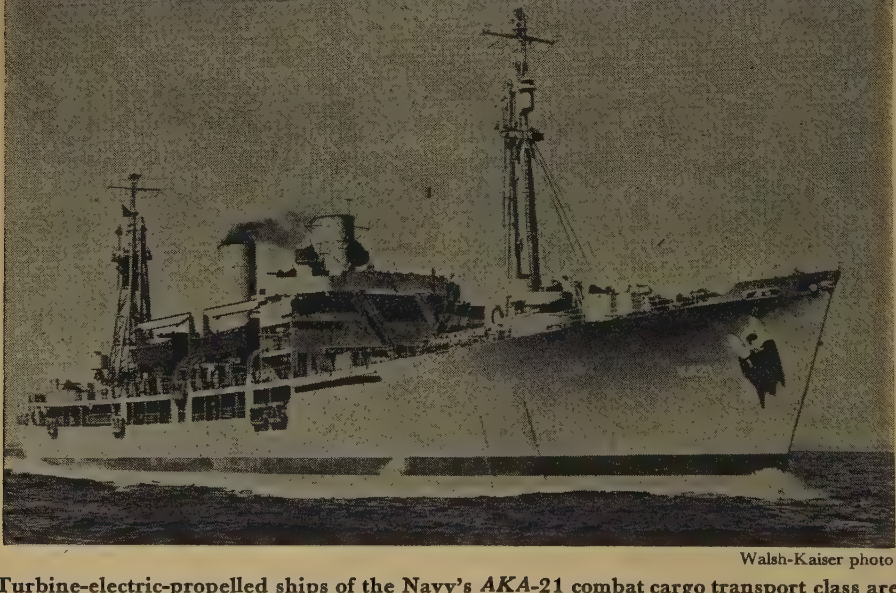
Assurance of continuous power for military operations was the main consideration behind the move which established a setup patterned after the grid system in force in England for the last 15 years and once proposed for the Tennessee Valley Administration.

Power failures have been prevalent in Italy from either mechanical weakness or other causes reflecting the fact that the plants were patched together with many parts from many regions. These stoppages often brought the work of military establishments to a halt, despite the fact that next door or across the street operations powered by other companies were uninterrupted. It also was found that some areas with a low military urgency had surplus power, whereas others with high military priorities had insufficient power. Adoption of the central control system has effected an equitable distribution of all available power.

Conversion encountered many difficulties among which was the differing frequencies and voltages used by the various companies. A uniform frequency of 45 cycles has been established, and, although the expected variations have occurred, conformity with it now is generally maintained.

The new scheme has been a boon to many small but essential industries, which have been able to produce only at reduced capacity as the bulk of the power in the areas in which they are located was taken by military establishments and large essential industries.

Cargo Ships Use Packaged Power



Walsh-Kaiser photo

Turbine-electric-propelled ships of the Navy's *AKA*-21 combat cargo transport class are fitted with a packaged power plant which is lowered into the hull complete. The unit contains a turbine, generator, and condenser. Even the lubricating oil system, pumps, and piping are included. The small bulk of the turbine generator is made possible by its speed of 4,800 rpm

INDUSTRY • • • • •

Bell System Facilities Devoted to War Effort

With extension of telephone service seriously hampered by shortages of central-office equipment, outside lines, and telephone instruments, one of the most consistent expansions occurred near military establishments, according to the annual report of the American Telephone and Telegraph Company for 1944. During the year special attention was given to service men returning from overseas, and particular emphasis was placed on meeting the needs of wounded and convalescent patients in Army and Navy hospitals. At many hospitals, portable bedside service is provided, and attended public telephone centers are equipped with such special features as booths large enough to accommodate a wheel chair or bed, amplifying equipment for the hard-of-hearing, and chest transmitters and head receivers for patients unable to hold the usual type of telephone.

Through longer experience in handling wartime traffic and greater skill in using available facilities, the average time required to complete long-distance calls was reduced in 1944 to 3.2 minutes from 3.7 minutes in 1943. This reduction reversed the trend of the three previous years. The proportion of toll and long-distance calls completed while the calling party remained at the telephone was increased to 85 per cent from 82 per cent in 1943, Bell System reports. The number of toll and long-distance calls rose 8.3 per cent above 1943, and the number of long-distance conversations handled by the long-lines department was 18 per cent more than in 1943. The total was almost as many as the department handled in the combined years, 1938, 1939, and 1940.

During the year overseas radiotelephone service was extended to the island of Trinidad, and further reductions in rates were made for service to the Caribbean area and most of the countries in Central and South America. A start was made on a second transcontinental cable, which will follow a southern route from New York through Atlanta and Dallas to Los Angeles. Telephone facilities along the Pacific Coast and on routes connecting with the East were reinforced to assure meeting military needs of the war with Japan. Among the additions were considerable dial and manual local-exchange equipment, 600 additional toll circuits (principally between the larger cities), and toll switchboards.

Bell Telephone Laboratories divided its year's war work with 55 per cent for the Army, 35 per cent for the Navy, and about ten per cent for the Office of Scientific Research and Development. Special recognition for the Laboratories School for War Training came in a decision of the Navy to assign at least one officer graduate of the school to every major combat ship. Nearly 4,000 Army, Navy, and Marine Corps personnel have been trained in the school, where instruction books and maintenance manuals also are prepared.

An electric antiaircraft-gun director devised by the Laboratories and adopted as standard by both British and American armies was instrumental in lessening the robot-bomb menace in England in the past year.

The report merely mentions the most probable lines which postwar research will take, since peacetime research has been abandoned for the duration. Wartime progress in very short radio waves indicates further experimentation in that direction. The communication possibilities of microwaves will be tested on a radio relay system between New York and Boston for which the Bell System has obtained experimental licenses. Intermediate relay sites have been secured and, as soon as the war permits, construction will be started. Television transmission also may be feasible by this method, the report states.

The Western Electric Company has raised the percentage of its total sales going to the United States Government from 83 per cent in 1943 to 85 per cent in 1944. Sales to the Bell Telephone Companies, though higher than in 1943, were limited to repair and maintenance equipment, new facilities authorized on a priority basis, and the limited number of telephone instruments made for civilian use in the last quarter of the year. At the end of the year the company was producing war equipment, not only at its three main factories, but also in 22 satellite plants leased in 15 cities. In many of its distributing houses, repair-shop facilities were pressed into service for war production. War equipment produced by the company in the last five years includes 5,000,000 military telephones, of which 1,250,000 were head sets for aviators and tank crew men; more than 1,000,000 airplane radio transmitters and receivers; 3,750,000 miles of telephone wire in cables; over 50,000 teletypewriters; and a vast quantity of switchboard, radar, gun-director, and secret combat equipment.

British Employ Underground Cable for 132-Kv Installation

A trial underground cable to carry current at 132 kv recently was installed on the system of the Central Electricity Board in Yorkshire, England, where the variations of load impose a particularly stringent test.

The history of the new compression-type cable dates from about 13 years ago. It was developed to eliminate cable breakdown from ionization made possible at high pressure by the formation of voids in the insulation as a result of the expansion and contraction of the cable under load cycles.

As a remedy the lead sheath of the cable was subjected to an external gas pressure which forces the lead sheath back to its normal position when the temperature of the cable falls, thus preventing the formation of voids. In the early designs the cable was drawn into a continuous pipe of welded steel, filled with nitrogen gas under pressure. In more recent forms the cables are complete in themselves. The usual lead sheath is reinforced and surrounded with another reinforced sheath, and the space between the sheaths is filled with high-pressure gas. Not only is this a more compact and convenient arrangement, but also it has the advantage of excluding all gas from the insulation itself.

The first commercial installation of the early pipe-drawn design was made in London 12 years ago, when a 66-kv link was laid between two power stations in a congested area where overhead lines were not practicable.

Bell System Statistics

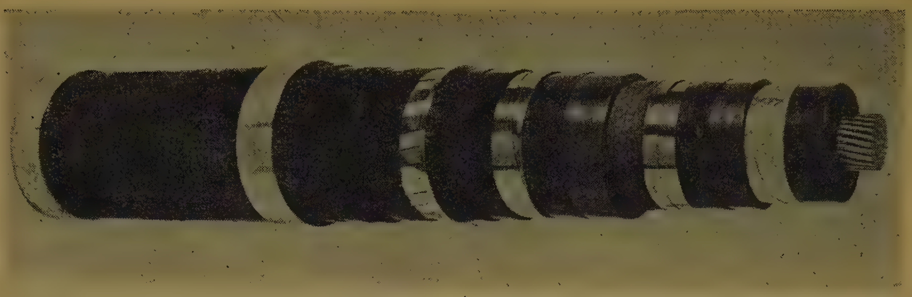
	December 31, 1925	December 31, 1930	December 31, 1935	December 31, 1940	December 31, 1944	Increase During 1944
Number of telephones **	11,909,578	15,187,296	13,573,025	17,483,981	21,580,345	333,716
Number of central offices	6,147	6,639	6,896	7,052	7,342	31
Miles of pole lines	394,529	428,212	407,454	399,838	414,418	2,137
Miles of wire:						
In underground cable	27,769,000	45,116,000	47,639,000	54,339,000	59,918,000	597,000
In aerial cable	12,835,000	23,777,000	26,425,000	30,307,000	33,357,000	246,000
Open wire	4,339,000	5,231,000	4,562,000	4,660,000	4,953,000	15,000
Total	44,943,000	74,124,000	78,626,000	89,306,000	98,228,000	858,000
Average daily telephone conversations* ‡	50,141,000	64,034,000	60,290,000	79,303,000	86,059,000	(98,000)†
Total plant	$2,566,809,000	$4,028,836,000	$4,187,790,000	$4,747,674,000	$5,512,395,000	$124,605,000
Operating revenues*	$ 737,560,000	$1,075,228,000	$ 919,116,000	$1,174,322,000	$1,769,705,000	$121,628,000
Taxes*	$ 58,113,000	$ 84,732,000	$ 94,507,000	$ 184,770,000	$ 417,468,000	$ 44,532,000
Number of employees §	292,902	318,119	241,169	275,317	337,863	(5,117)†
Number of American Telephone and Telegraph Company stockholders	362,179	567,694	657,465	630,902	668,013	16,302

† Decrease. * For year ending December 31.

** Excludes private line telephones numbering 96,704 on December 31, 1944. Including telephones of about 6,100 connecting companies and more than 60,000 directly and ndirectly connecting rural or farmer lines and systems, the total number of telephones in the United States which can be interconnected is approximately 26,800,000.

‡ For the year 1944 there were approximately 81,826,000 average daily local conversations and 4,233,000 toll and long distance conversations, a decrease of 0.5 per cent and n increase of 8.2 per cent, respectively, over the year 1943.

§ In addition the Western Electric Company and the Bell Telephone Laboratories had 101,869 employees on December 31, 1944.



Telescopic sample of the 132-kv compression cable made by the Enfield Cable Works, Ltd., London, England

In 1941 a self-contained cable, again at 66 kv, was introduced and design commenced on cables of the same type capable of transmission at 132 kv, which is the voltage adopted by the Central Electricity Board for its main transmission lines.

This cable, which is now on trial, has three separate cores laid round a field, and the conductor in each core has a current-carrying capacity of 324 amperes. The insulation is composed of layers of impregnated paper finished with metallized paper, and the whole is encased in a thin lead sheath reinforced with two copper tapes. Oval construction has been adopted in order to facilitate the free expansion and contraction of the cable. The gas-retaining lead sheath which surrounds the inner sheath is circular in section and is reinforced with two brass tapes lapped over oiled paper as well as with narrow longitudinal tapes. Two layers of nonfibrous insulating material (impervious to water and to dilute acids and alkalies), reinforced with cotton tapes and finished with impregnated hessian, complete the cable, which has an over-all diameter of about eight centimeters.

The cable is terminated in stabilized bushings of a novel type. These contain oil at a pressure equal to that of the gas in the cable and are fitted with a compensator (consisting of a bellows, filled with oil and surrounded with gas, connected to the intersheath space) which automatically balances the pressures of the oil and the gas. Gas is supplied to the cable from gas cylinders through a pressure-control valve, and a relief valve is provided to release any excess of pressure due to a rise in cable temperature. The tests applied to the cable in the factory were of the usual type, including a d-c test at 264 kv and an a-c test at 105 kv, both being for 15 minutes.

The success of the cable is expected to have a marked influence upon the design of future networks for the transmission of electricity in bulk.

Westinghouse Magazine in Portuguese. Westinghouse Electric and Manufacturing Company will issue a bimonthly Portuguese technical magazine, *O Engenheiro Westinghouse*, scheduled to start publication April 1, in addition to its Spanish magazine, *El Ingeniero Westinghouse*, already in existence. Like the Spanish magazine, the new Portuguese publication, will be made up of translations of articles from recent issues of the *Westinghouse Engineer*, plus additional information of special interest to technical readers in Brazil and other Portuguese-speaking countries.

Award Program Announced for Design Textbooks

A $20,000 award program, intended to encourage the preparation and publication of textbooks, one on machine design and another on structural design for fabrication by all processes, including welding, has been announced by The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.

Manuscripts may be submitted by any person in the teaching profession, industry, or in private consultation, and may be a revision of an existing textbook. There are three awards in each class; a first prize of $5,000, a second prize of $3,000, and a third prize of $2,000. Among the factors upon which the awards will be based are the educational value and utility of the proposed book, adequacy of coverage, and completeness and thoroughness of treatment consistent with proper length for collegiate use. The award program closes May 15, 1946. Further details may be obtained from the secretary of the Foundation, Cleveland 1, Ohio.

Biddle Company Has 50th Anniversary. With the publication of a brochure entitled "Report at Mid-Century," the James G. Biddle Company, Philadelphia, Pa., announces the celebration of its 50th year in the electrical instrument business. The entire career of the firm has been under the direction of James G. Biddle (A '96), founder of the business. "Report at Mid-Century" presents an informal discussion of Mr. Biddle's professional achievements since the inception of the organization on February 22, 1895.

HONORS ● ● ● ● ● ●

Dugald C. Jackson Celebrates 80th Birthday

On the occasion of the 80th anniversary of his birth, Dugald C. Jackson (F '12), professor emeritus of electrical engineering, the Massachusetts Institute of Technology, and past president of the AIEE, was guest of honor at a birthday banquet held on February 13, 1945, at the Engineers Club, Boston, Mass. Karl T. Compton (F '31), president, the Massachusetts Institute of Technology, presided, and speakers included A. Pen-Tung Sah (M '36), president, National University of Amoy, China; Harold L. Hazen (F '43), head of the department of electrical engineering, Edward L. Moreland (F '21), dean of engineering, and Carlton E. Tucker (F '39), executive officer, department of electrical engineering, all of the Massachusetts Institute of Technology; and Joseph W. Barker (F '30), dean, Columbia University, New York, N. Y.

In addition to the tributes to his ability and accomplishments offered by those present, Professor Jackson received 174 letters of greeting and appreciation from various societies, friends, and former students, which were presented to him in a volume bound in tooled leather. He also was presented with a set of the Encyclopaedia Britannica on behalf of the engineering firm of Jackson and Moreland.

All arrangements for the banquet were made by Mr. Tucker.

JOINT ACTIVITIES

Schenectady Engineering Council Completes History of Growth

With the printing of its constitution, the Schenectady Engineering Council completes a series of articles in the Schenectady Engineering Council *Bulletin* outlining the history of the growth of the council and describing its aims and activities. The council is a continuation of the old co-ordinating committee of AIEE, the American Society of Mechanical Engineers, the American Welding Society, and the New York State Society of Professional Engineers, which has functioned since 1936. Because its objectives and membership have been broadened to include the interests of the community, as well as all technical and scientific persons, it has been felt important to publish this series in order to acquaint the societies, their members, and the community in general with the new organization.

The Schenectady Engineering Council supports the functions of its member societies which overlap the many branches of engineering and science. On a voluntary basis, the societies each organize one general meeting at which they are hosts to all the societies. Five societies are participating this year. Previous issues of the *Bulletin* have presented a combined program calendar for the year including the programs of all member societies, a directory of officers and committee chairmen of the council and of member societies, and a statement of finances including last year's expenses, the budget for this year, and expected net cost. This is the first year under the new council with over-all self-supporting management.

Reading List Issued by ECPD for Junior Engineers

A revised "Reading List for Junior Engineers," reprinted in a convenient form from the 12th annual ECPD report, has been issued by the junior committee on Professiona Training of the Engineers' Council for Professional Development. The list is a revision of the original 1936 list and covers natura science; philosophy, including religion economics and sociology; psychology; business and industrial management; literature, including poetry, essays, and fiction; history; biography; travel; and the fine arts.

The reading list accents study in the cultural and intellectual fields outside of the specific profession and so eliminates textbooks and encyclopedic works, as well as current "best sellers." In the latter instance, five modern books will appear each year on a mimeographed addenda to the printed listing. After five years on the addenda, the book will be transferred to the master reading list or eliminated.

Copies of the "Reading List for Junior Engineers" are ten cents each (five cents in lots of 50 or more) and may be obtained from the Engineers' Council for Professional Development, 29 West 39th Street, New York 18, N. Y.

OTHER SOCIETIES •

Resistance-Welding Prize-Paper Contest Announced

Four prizes amounting to $1,000 for resistance-welding technical papers are being offered by the Resistance Welder Manufacturers Association, Philadelphia, Pa.

The first prize of $500 will be awarded for the best paper from an industrial source, consulting engineer, government laboratory, or the like, in which the subject matter is concerned with design for resistance welding. Two $200 prizes will be awarded for papers offering the greatest contribution to the advancement and use of resistance welding, one to an instructor, student, or research fellow at a recognized university, and the other to an industrial contributor. A fourth prize of $100 will be awarded to the author of the best remaining paper in any of the three groups. The contest closes July 31, 1945, and the awards will be announced at the October annual meeting of the American Welding Society. Further particulars may be obtained from Harold S. Card, educational director, Resistance Welder Manufacturers Association, Cleveland 14, Ohio.

Chairmen Named for Building Campaign. W. R. G. Baker (M '41) vice-president, General Electric Company, Bridgeport, Conn., has been named head of the initial gifts committee for the Institute of Radio Engineers campaign to raise $500,000 for a headquarters building in New York City. Powel Crosley, Jr., president, Crosley Corporation, Cincinnati, Ohio, has been appointed honorary campaign chairman.

Simplified Perpetual Calendar Proposed

A Perpetual Calendar which not only will divide the year into precisely 52 weeks but will enable one to compute all future dates without a printed calendar, has been devised by Lieutenant Willard E. Edwards, United States Naval Reserve, and has reached the Congress of the United States as a Concurrent Resolution requesting the President to urge its adoption at the peace conference.

The proposed method would correct the irregularities of the present calendar by setting aside the first day of the year as a day apart from any week or month and thus permitting division of the remaining 364 days into exactly 52 weeks. The result is that the half-years then become equal, the quarters become equal, and the months fall into the regular rhythmical pattern of 30, 30, 31. The first day of the year, New Year's Day, would therefore be celebrated as a day in itself between December 31 and the second day of the year, Monday, January 1.

The same solution is employed for the extra day in leap year by designating the day following Sunday, June 31, as Leap Year Day so that the year may be divided into two equal parts of 183 days each. Under this arrangement, the first month of each quarter always begins on Monday, the second month on Wednesday, and the third on Friday; and holidays and anniversaries will always fall on the same day of the week as well as the same day of the month. In addition, Monday on the Perpetual Calendar becomes the first day of the week and Sunday the last.

Under the Edwards plan, three three-day holiday periods would occur during the year, Christmas, New Years Day, and Easter, with an additional three-day holiday during Leap Year. Monday, April 15, would be celebrated as Easter Day, a universal legal holiday following Easter Sunday, April 14, which provides the third holiday weekend of the year. Lieutenant Edwards also has suggested that Monday, February 13, be celebrated as "Presidents Day," a nation-wide legal holiday in memory of all past Presidents

THE EDWARDS PERPETUAL CALENDAR

• **NEW YEAR'S DAY (a day apart from any week or month) is the first day of each year, a holiday, followed by the 364-day fixed calendar shown below:**

JANUARY

M	T	W	T	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

FEBRUARY

M	T	W	T	F	S	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

MARCH

M	T	W	T	F	S	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

APRIL

M	T	W	T	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

MAY

M	T	W	T	F	S	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

JUNE

M	T	W	T	F	S	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

• **LEAP-YEAR DAY (a second day apart) is observed only in leap years between June 31 and July 1 as the first day of the second half-year, a holiday.**

JULY

M	T	W	T	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

AUGUST

M	T	W	T	F	S	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

SEPTEMBER

M	T	W	T	F	S	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

OCTOBER

M	T	W	T	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

NOVEMBER

M	T	W	T	F	S	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

DECEMBER

M	T	W	T	F	S	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

• **These two YEAR-DAYS are definitely named and have a definite purpose. When considered apart from any week, they allow the calendar to become fixed and perpetual.**

A Proposal for a New, Up-to-Date Calendar

RESEARCH • • • • •

Laboratory to Be Established for Precision Measurements

An initial grant of $15,000 has been made to the Illinois Institute of Technology by the Ohmite Manufacturing Company for the establishment of a laboratory for precision measurement of electrical and magnetic quantities, according to Henry T. Heald, president of the university.

The laboratory's goal is to provide precision electrical measurements for the Chicago area approaching in accuracy those of the Bureau of Standards in Washington, D. C. Industries in the vicinity will have the opportunity to use the laboratory's facilities. The laboratory will be located in the engineering building of the Armour Research Foundation of the institute and will be under the direction of E. H. Schulz (A '37) supervisor of electrical-engineering laboratories, and L. W. Matsch (M '41) supervisor of electrical engineering in the foundation.

Chemical Encyclopedia to Be Published in English

Set up as a five-year project, the Encyclopedia of Chemical Technology, now in preparation in this country, will be designed specifically for use in the Americas, according to announcement by the coeditors, Raymond

E. Kirk, head of the department of chemistry and dean of the graduate school, and Donald F. Othmer, professor of chemical engineering and head of the department, Polytechnic Institute of Broklyn.

To sponsor the project, a new corporation, the Interscience Encyclopedia, Inc., has been established by Interscience Publishers. According to Doctor Kirk, no encyclopedia of chemical technology in the English language exists; the only equivalent to the proposed work at present available is a German encyclopedia. It is proposed that the new encyclopedia will be a 10- or 12-volume set, and the first volume is scheduled to appear in April 1946.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here-in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

The Engineer and His Future

To the Editor:

The proposal to form a professional society to promote the interests of all engineers has been given an impetus by the article in the January 1945 issue of *Electrical Engineering* by AIEE President Powel (pages 14–16). This proposal, it seems to me, should be given very serious consideration by members of all the engineering societies. The needs for some such organization are so obvious that they hardly need to be mentioned; however, the nature of the organization to be formed and the policies that it is to pursue call for the fullest discussion and the exercise of greatest discretion. The matter is so complex and the implications so far reaching, that we may be compelled to bring our whole economic setup under scrutiny before a satisfactory program can be formulated.

Under the present organization of business and industry, the engineer stands in a peculiar relationship to his employer. In one sense the engineers, or at least the majority of them, have the same relationships to their employers as do members of the Congress of Industrial Organizations or the American Federation of Labor; that is to say they are hired to render certain services to their employer and are paid a definite wage as agreed upon. In another sense, however, the engineers as a group stand with the owners and managers of industry and against the employee groups that are found in the AFL and CIO. This conflict of interest appears when an engineer in the normal pursuit of his profession installs a more efficient machine or works out a labor-saving process for his employer. If a laborer be eliminated or even if only the grade of skill required be lowered by the innovations made by the engineer, the labor unions will oppose these changes.

The engineer will have to decide against his profession or else take a stand against his union. Whether the labor union attitude is just or reasonable does not matter. As long as the present management-labor relations are maintained, these conflicting interests will persist. If the engineers choose to join a labor union, they will find themslves in a conflict where loyalty is bound to waiver. As an alternative, they can form their own professional organization. This is not a matter of "dodging the issue" but is only a frank recognition of the fact that engineers stand in a unique relationship to both management and labor. This relationship is not paralleled by the bar association, the medical association or by the membership of any other professional society. The engineers will have to set up their own organization and formulate its policies. This organization must not be patterned too closely after any now in existence but must be suited to the needs of the engineering group and to the public welfare.

With this organization strongly established and winning acceptance, the engineers will be in a much better position to attack those problems of industry and of labor that merit their attention. For them to attempt to throw their support to any labor organization as now constituted would be to invite disaster. There are too many who would see the conflicting situation into which they would be thrown and so would not join, or if they did join would be half hearted in their support of it. The inferiority of numbers and the lack of enthusiasm for some of the labor-union activities would so submerge the group that joined as to make their efforts useless. An organization exclusively for engineers seems essential.

G. H. SECHRIST (A'20)

(Staff member, radiation laboratory, Massachusetts Institute of Technology, Cambridge, Mass.)

Proposed Canons of Ethics for Engineers

To the Editor:

Permit me respectfully to submit some comments relating to the "Proposed Canons of Ethics for Engineers" published in a recent issue of *Electrical Engineering* (*Dec '44, p 442*).

It is difficult to understand why a separate code of ethics is needed for any specific group of people; why general ethics, the Ten Commandments, the Golden Rule, and so forth, are not enough ethics for anyone. It is particularly difficult to understand why engineers need a special code of ethics.

Engineers are notoriously more ethical than most people, not by nature but by training and necessity. Engineers are trained to disciplined thinking, and disciplined thinking, which is logical thinking, is bound to result in ethical thinking, because ethical thinking is synonymous with logical thinking. Engineers are of necessity ethical, because a mistake made by an engineer can be traced to him from his own records even after he is dead.

There is a considerable difference between lawyers and doctors on one hand, and engineers on the other hand. Lawyers and doctors are independent individuals, the majority of engineers are doomed to be employees, and it may be a better idea to have a code of ethics for those who employ engineers than one for engineers. There is a particular difference between the lawyer and the engineer as regards ethics. The basic idea of the lawyer is to *prove* something. The basic idea of the engineer is to *find* something. When there is a dispute between two people, the lawyer takes the case of the one who comes to him first and has to try to prove that he is right. The engineer generally has to find out *what* is right, no matter who his client is. So, basically the engineer is forced to be ethical whether he likes it or not. However, I see no harm in having a code of ethics for engineers, and most of the clauses, platitudinous as they may be, will probably cause no harm.

The only possible objection that could be raised is against the provision that an engineer should not criticize the engineering done by another engineer. Why not? When I see that an engineer recommended that my friend build something which is not sound, perhaps even hazardous, why can't I tell my friend, if I don't collect any fee from him or even if I do? Why can't I criticize some nonsensical engineering in a piece of public works? Can't I even criticize a piece of engineering described in the engineering literature? Why not? Are some incompetent engineers, by any chance, afraid of criticism? Any engineer should be glad to expose any engineering to public criticism. It will help him in his future work. Will it be unethical for an engineer to debunk cranks, nuts, quacks, fakers, and the like? But most important of all, if we do have a code, let us do something to kill the two snakes which have been the curse of the engineering profession:

1. The vicious habit of some engineers of collecting a fee or a salary for doing an engineering job and then permitting manufacturers' representatives to do the engineering for them gratis.

2. The vicious habit of some engineering companies of permitting a few engineers to swivel in their chairs without any responsibility while the draftsmen do all the engineering. This practice goes even further. They advise an engineer who applies for a job that there is no opening in the engineering office, but that there is an opening in the drafting room. They hire him as draftsman at low pay, put him in the drafting room, and make him do all the engineering. I even have heard some executives brag about how smart they are to do just that.

Why not do something about these two offenses in the code, if we are to have a code?

M. M. SAMUELS (F '24)

(Chief, technical standards division, Rural Electrification Administration, St. Louis, Mo.)

The Engineering Degree

To the Editor:

The letters in *Electrical Engineering* of Harold M. Gould (*July '44, p 278*) and Carl G. Jones (*Sept. '44, p 352*) concerning engineering degrees are of considerable interest to me since they are illustrative of the desire of a large number of practicing engineers to obtain an advanced degree. The accomplishments of many of these engineers in research, theory, and design are at least equal to and in many cases more advanced than the work for which the master's and even the doctor's degrees usually are awarded. As is well known, a degree is a title conferred by a school, college, or university as a mark of proficiency in scholarship. Degrees originated sometime in the 13th century and undoubtedly resulted from the practice of mechanics' corporations in which the apprentice, after serving his time, received a testimonial of his skill. In modern times, so far as the writer is aware, the prerogative of granting degrees in the United States has always been confined to educational institutions and has not been assumed by other organizations, even though they be professional or scholarly in their objectives. In the United States the right to grant degrees is conferred on the educational institution by the state legislatures.

In Mr. Jones's opinion there is a widespread granting of degrees with such low requirements that the scientific profession is being cheapened. I believe, however, that the tendency is distinctly in the opposite direction. It is true that engineering degrees have been granted for work of standards and now are considered low and also that at the present time there is considerable variation in the requirements for the same degree. However, during the past few years there has been a distinct raising of engineering school standards and of the requirements for the degrees. This may be attributed to several causes. The art of engineering, particularly electrical engineering, has advanced tremendously in the past few years, because of the availability of such new scientific developments, as electronics, high frequencies, X-rays, and new materials. These new developments have compelled engineering schools to raise the standards of the scientific content of their courses in order that their graduates may meet the increasing demands of the art. Also, standards have been stimulated by educational meetings and conferences, such as those sponsored by the Society for the Promotion of Engineering Education, the Engineers Council for Professional Development, and the technical societies where representatives of industry as well as educators have presented their views on what engineering education should be. In addition, the accrediting program under ECPD in many cases has raised educational standards as well as the physical equipment of engineering laboratories.

Hence, I believe it may be said that at the present time, although perfection in standards for the degree among engineering schools has not by any means been reached, yet the tendency is toward strengthening the requirements rather than cheapening them, as is stated by Mr. Jones. Also, to me, the plan advocated by Mr. Jones, whereby the professional societies assume control of the granting of higher degrees, seems impracticable. As has been stated above, the granting of degrees is a long-established right of educational institutions and is controlled by the state legislatures, and neither is likely to surrender this prerogative. Also, I feel that Mr. Jones's scoring table in some respects is quite unfair. For example, only one point is allowed for the college master's degree and two points for the college doctor's degree. In most cases these degrees represent respectively five years or more, and seven years or more, of "sweat and blood," yet the points awarded are equivalent to a single patent, or a scientific paper, the values of which are sometimes doubtful. A single patent or a scientific paper indicates, usually, a knowledge of a specific subject, whereas an advanced degree necessitates a thorough knowledge in a wide field.

Mr. Gould suggests that schools should shorten the vacations so that a master's degree may be obtained in four years. Offhand, this suggestion appears to have merits, but experience with accelerated wartime programs has shown that most students cannot maintain high scholastic levels under the steady strain of a sustained program. Also, with accelerated programs several educational values are lost, such as time for reflection and absorption, time for participation in many desirable extra-curricular activities, and opportunities for industrial experience, all of which unquestionably add to the breadth and full development of the student. Several of the students in wartime training leave the institutions saying that they want to come back and "really absorb" the material which has been covered. Also, it is necessary for a large number of the students to work during the summer vacations in order to meet part of their college expenses. Hence, as desirable as it may appear to operate educational plants on a 12-month basis, nearly all are planning to revert to the two-term academic year after the needs of the war and of the returning veterans have been met. With graduate students, however, most engineering schools do permit work in the summer vacation in order to expedite the work toward the degree.

Mr. Gould also suggests that advanced degrees be obtained by correspondence courses. There is no doubt that such courses, if pursued faithfully, would be highly beneficial and would meet the educational needs of numbers who have no other access to advanced study. The objection to granting advanced degrees for such work is that a degree connotes much more than the mastery of the content of courses. There are several intangible values, such as contacts with the teachers and their influence on the student and his ways of thinking, the use of libraries, contacts with other students, and acquaintance with the customs and traditions of the institution. Also, the work for advanced engineering degrees should involve laboratory and research work, which are not readily accomplished from a distance.

To me, however, it seems that both of these letters express a more or less widespread and innate desire on the part of many engineers in industry who are ambitious and whose scholastic attainments and contributions to the art should receive recognition by advanced degrees and that avenues should be made available for obtaining such degrees. Engineering schools already have made some attempts to meet the situation. In a few industrial centers evening courses and co-operative courses sponsored by industries and engineering schools are available for graduate study. However, it is doubtful if demand will permit the extension of this practice beyond a relatively few industrial centers. Also, the committee on professional training of ECPD sponsors postgraduate training of students in industry, although means for awarding degrees are not always available in those programs. In the matter of difficulty of returning to school for an advanced degree, the "year of graduate study" to which Mr. Gould refers means an academic year consisting usually of only eight months. Hence, it is sometimes possible for a practicing engineer to arrange a part-time leave of absence in order to obtain an advanced degree. In the work for the doctor's degree a large proportion of the time is required by the thesis. Many schools now permit a large part of the research and preparation of the thesis to be done outside. Hence, efforts are being made to meet the situation, but, nevertheless, there are still wide opportunities for industry and the engineering schools to co-operate more closely so as to make available more avenues by which practicing engineers may obtain recognition for professional accomplishments.

In my opinion there would be greater satisfaction among many practicing engineers who feel that their attainments are worthy of an advanced degree, if they obtained at least the master's degree before entering industry. Many of the leading engineering educators agree that now it is practically impossible in a four-year program to prepare students to meet the existing advanced developments in science and technology. In the "Report of the (SPEE) Committee on Aims and Scope of Engineering Curricula"[1] it is stated:

> "Preparation for the higher technical levels of engineering . . . clearly requires more than a four-year period and should extend beyond the baccalaureate degree."

The engineering schools are making every effort to encourage students of scientific ability to remain for graduate work. Financial aids are being extended by the granting of liberal scholarships, fellowships, and part-time teaching and research assignments, so that nearly any able and ambitious student now can continue his graduate studies, irrespective of his financial status.

The greatest handicap to graduate study is industry itself. The personnel representatives visit the schools and make alluring financial offers to undergraduates, particularly to those who have outstanding ability and, hence, who are best adapted to remain for graduate work. These students are advised that further engineering training will be provided by the industry, that the student will be paid while learning, and that further degrees are not important. With such temptations it is difficult to persuade students to continue academic study and undoubtedly many of them later will be in the category of those for whom Mr. Jones and Mr. Gould are speaking. They have shown that they are highly qualified for a higher degree but that no avenue for obtaining it will be readily available to them.

Mr. Jones and Mr. Gould have, I believe, performed a service in calling attention to an existing deficiency in postgraduate engineering education, and I am certain that all engineering educators are in sympathy with any operative plan that will remedy the situation and at the same time will not jeopardize in any way the ideals of scholarship for which the degrees are symbols.

REFERENCES

1. Report of the Committee on Aims and Scope of Engineering Curricula. The Society for the Promotion of Engineering Education *Journal of Engineering Education*, volume 30, March 1940, page 555.

2. Report of Engineering Education After the War. The Society for the Promotion of Engineering Educa-

tion *Journal of Engineering Education,* volume 34, May 1944, page 589.

CHESTER L. DAWES (F'35)

(Associate professor of electrical engineering, graduate school of engineering, Harvard University, Cambridge, Mass.)

NEW BOOKS ● ● ● ●

The following new books are among those recently received from the publishers. Books designated ESL are available at the Engineering Societies Library; these and thousands of other technical books may be borrowed from the library by mail by AIEE members. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books. All inquiries relating to the purchase of any book reviewed in these columns should be addressed to the publisher of the book in question.

Radio's 100 Men of Science. By O. E. Dunlap. Harper and Brothers, New York, N. Y., and London, England, 1944. 294 pages, illustrated, $8^3/_4$ by $5^3/_4$ inches, cloth, $3.50. (ESL.)

The brief biographies in this readable book cover a wide field. The first section is devoted to pioneers of electricity, from Thales of Miletus to Mahlon Loomis. The second section traces developments in radio and electronics from Hughes's invention of the microphone to the present day. The sketches are good and are in many cases based on personal acquaintance. Nearly one half of the men are living. Portraits of almost all of them are included.

Alignment Charts. By M. Kraitchik. D. Van Nostrand Company, New York, N. Y., 1944. 94 pages, illustrated, $9^1/_4$ by 6 inches, cloth, $2.50. (ESL.)

The opening section of this book provides a review of the algebra, analytic geometry, and determinants necessary for an understanding of the methods of chart construction. The representation of various equations then is discussed and illustrated by means of exercises. Applications are made to the fields of chemistry, engineering, manufacturing, and investments. Some of the charts given are ready for use.

Peace, Plenty, and Petroleum. By B. T. Brooks. Jacques Cattell Press, Lancaster, Pa. 1944. 197 pages, illustrated, $7^3/_4$ by $5^1/_4$ inches, cloth, $2.50. (ESL.)

After a brief historical survey of the American petroleum industry, the author devotes several chapters to the importance of petroleum in our industrial economy with particular reference to war needs. Petroleum substitutes are discussed, and the geographical distribution and political implications of petroleum deposits are thoroughly covered. The author emphasizes the steady decrease in new producing areas in the United States and discusses the problems arising in connection with the increase in our need for foreign oil.

Rocket Research. By C. P. Lent. Pen-Ink Publishing Company, New York, N. Y., 1944. 102 pages, illustrated, $9^1/_4$ by 6 inches, stiff cardboard, $5. (ESL.)

The early history and present status of the development of rocket and jet propulsion are well presented in this small volume. The author covers both theory and practical application, including descriptive material on the various types of weapons brought out by the war. The text is illustrated by more than 100 photographs and diagrams, and some 150 American and British patents are listed.

Treatise on the Mathematical Theory of Elasticity. By A. E. H. Love. Fourth edition. Dover Publications, New York, N. Y., 1944. 643 pages, illustrated, $9^1/_2$ by 6 inches, cloth, $3.95. (ESL.)

This standard widely known treatise has been out of print for some time, and this republication will be welcomed by many engineers and physicists. It is an American reproduction of the latest English edition, complete in every respect, with the advantage of a greatly reduced price.

Solvents. By T. H. Durrans. Fifth edition. D. Van Nostrand Company, New York, N. Y., 1944. 202 pages, illustrated $8^3/_4$ by $5^1/_4$ inches, cloth, $6. (ESL.)

The first part of this book deals with scientific fundamentals: solvent action, solvent power, plasticizing solvents, solvent balance, viscosity, vapor pressure and evaporation rates, inflammability, and toxicity. The second part deals comprehensively with individual solvents, mainly with the view of facilitating intelligent use of them in the cellulose-lacquer industry. A table of solubilities and a dictionary of trade names are appended.

Metals and Alloys Dictionary. By M. Merlub-Sobel. Chemical Publishing Company, Brooklyn, N. Y., 1944. 238 pages, $8^3/_4$ by $5^1/_2$ inches, cloth, $4.50. (ESL.)

Over 10,000 useful metallurgical terms are contained in this reference volume: definitions of metallurgical terms; compositions, properties, and uses of all important commercial alloys; physical constants and properties of the chemical elements; brief descriptions of machinery and processes used in modern metallurgy; and others. Many trade names are included.

Prodigal Genius, the Life of Nikola Tesla. By J. J. O'Neill. Ives Washburn, New York, N. Y., 1944. 326 pages, illustrated, $8^3/_4$ by $5^3/_4$ inches, cloth, $3.75. (ESL.)

This book is concerned chiefly with Tesla's talent as an inventor. It describes not only his discoveries within the field of electricity but also his work in other fields. Giving full credit to his status as a brilliant engineer, it also portrays the eccentricities which almost equally set him apart from the normal run of human beings. As the book shows, both aspects were in evidence quite early in his life.

Clouds, Weather, and Flight. By T. C. Gillmer and H. E. Nietsch. D. Van Nostrand Company, New York, N. Y., 1944. 161 pages, illustrated, $11^1/_4$ by $8^1/_2$ inches, cloth, $3.75. (ESL.)

The contents of this book represent a development of the basic physical laws of the atmosphere into the principles of air-mass analysis and forecasting. Part I covers this material generally for the layman. Part II considers the application of the study of meteorological conditions to aviation, with a special chapter on weather hazards. Part III discusses gliding and soaring flight. The book is illustrated copiously and has a glossary of meteorological terms.

Aerodynamics. By L. R. Parkinson. Macmillan Company, New York, N. Y., 1944 112 pages, illustrated, $8^1/_2$ by $5^1/_2$ inches cloth, $2.25. (ESL.)

This introductory work presents briefly both elementary and advanced phases of the science of flight. Beginning with the theoretical consideration of atmospheric properties and air flow over surfaces, the author continues with practical discussion of lift and drag, stability, and airplane performance The final chapter explains the construction and use of wind tunnels.

Galvanómetros y Oscilógrafos, Volume 1—Galvanometros. By S. Gerszonowicz. La Facultad de Ingenieria, University o Montevideo, Montevideo, Uruguay, 1943 Obtainable through G. E. Stechert and Company, New York 3, N. Y., and Editorial Médico-Quirúrgica, Buenos Aires, Argentina, 391 pages, illustrated, 10 by 7 inches paper, $6. (ESL.)

This book is a very detailed and encyclopedic discussion of galvanometers, especially from the viewpoint of the user. Their theories, construction, and performance are considered at length. Moving-magnet, moving-coil, and string galvanometers; electrodynamometers; induction instruments; and moving-iron and electrothermic instruments are discussed. A final chapter tabulates the data on current instruments found in the catalogs of 15 American and European manufacturers. Each chapter has a bibliography.

Treatise on the Analytical Dynamics o Particles and Rigid Bodies. By E. T Whittaker. Fourth edition, Dover Publications, New York, N. Y., 1944. 456 pages illustrated, $9^1/_2$ by 6 inches, fabrikoid $3.50. (ESL.)

This work long has been considered one of the best on its subject and has enjoyed wide use as a textbook and as a reference book for mathematicians and physicists The present publication reproduces the fourth edition, which appeared in 1937 at a reduced price.

PAMPHLETS ● ● ● ●

The following recently issued pamphlets may b of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers

Sound Films for Classroom Use. Bulletin 583. **Motion and Time Study Films.** Bulletin 582. State University of Iowa, Iowa City. 7 pages.

Postwar Planning for Metropolitan Utilities. John Bauer. National Municipa League, 299 Broadway, New York 7, N. Y. 31 pages, 35 cents per copy, four for $1, te for $2.

NAM Survey of Employment and Reconversion. National Association of Manufacturers, 14 West 49th Street, New York 20 N. Y., 17 pages.